



The Blast Furnace and Steel Plant

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The Blast Furnace *and* Steel Plant

Vol. X

PITTSBURGH, PA., JULY, 1922

No. 7

Control of Silicon in the Blast Furnace

Discussion Showing How the Composition of the Iron Is Regulated by Varying in General the Composition of the Charge and by Controlling the Temperature of the Hearth.

By S. L. GOODALE

Professor of Metallurgy, School of Mines, University of Pittsburgh

PART II

THE proper control of silicon is one of the most important factors in the management of quality of cast iron during the processes of manufacture. A great deal of study has been put on this subject over a period of many years. Most of this study has been carried on by plant investigators using the facilities of the various foundries with which they were connected, and securing, primarily, results of direct application to the solution of their own particular problems, and often of little further value. Most of the results of such studies have never been published at all, and when published are usually very difficult to compare because of the different conditions in the various places where the work had been done. Nevertheless, so much of careful comparison of results has been done that most of the various influences are now much better understood than formerly.

The influence of silicon for the most part is well understood in a practical general way, and the scientific explanation of its influence has been pretty well worked out. The equilibrium diagram of the iron silicon alloys was very carefully determined by Messrs. Guertler and Tamman some years ago, and Gontermann worked extensively and painstakingly on the diagram of the iron-carbon-silicon system.

Guertler and Tamman concluded, as a result of their own work and that of previous investigators, that silicon, up to some 18 per cent by weight, exists in iron as a compound of the composition Fe_2Si in solid solution in the iron. Commercial cast iron does not go over 4 or 5 per cent of silicon, usually much lower than that, and this part of the equilibrium diagram is sufficient for our present purpose. This investigation, of course, refers to the properties of pure iron-silicon alloys, and not directly and primarily to the influence of silicon on commercial cast iron. But in order to understand the effects of silicon on cast iron it will certainly be of use to know the kind of alloy that pure iron and pure silicon will make without other elements being present.

The very nearly pure iron silicon alloys are used for electrical purposes where high magnetic permeability and low hysteresis are desired and where high electric resistance is also useful. Such material is made into thin

sheets and then punched to the shapes needed for making the cores of transformers and armatures for dynamos and motors. Transformer core metal may contain up to 4.25 per cent of silicon, usually running about 4 per cent, and becoming rather brittle if it goes much above these limits, and the sheet for dynamo and motor core use contains usually about 1 per cent silicon in order to secure freedom from this brittleness, and because this sheet has often to have great physical strength and reliability. Power losses are cut down in two ways by using silicon steels for these purposes. The direct magnetic losses are lessened by the lower magnetic reluctance of the metal, and the stray current losses which cause heating of the cores are lessened by the high electrical resistance. In these cases it is the direct influence of the silicon on the iron that is of importance.

In commercial cast iron the effect of silicon on the condition of the carbon is of greater importance than its direct effect on the quality of the metal. In studying this subject it is necessary to realize that silicon does have at least two kinds of effects, which may or may not be independent of each other. It has firstly a direct influence when added to pure iron, as described in the paragraph above, and secondly it has the effect of a precipitant on carbon. Silicon, also, has an extremely high heat of oxidation, and because of this it is used in both iron and steel to act as a scavenger to remove oxygen and so assist in securing sound castings, but this use of silicon does not require much more silicon to be used than will be oxidized; and there is thus practically no silicon, or but very little indeed, really left in the metal because of this use. It is the second effect above mentioned that is most important to the iron foundry man, and with which this paper will mainly deal.

Commercial cast iron is a very complex alloy of some six principal elements, and a varying number of others, the importance of some of which at times is very considerable. Presumably each one of the elements entering into the composition of any cast iron has some effect or effects on the properties of that iron. And although cast iron has been known and carefully studied for so many years these effects are not yet fully known for

even the five principal alloying elements added to the iron in the metal. The reason for this is the great complexity of the subject, and the fact that there are usually other factors affecting the matter than the composition only as determined. This brings us to a question about which much controversy has raged, and that is, can one tell what the properties of a given pig iron will be from its analysis?

Can one tell the properties of pig iron from its analysis? Yes and no. Ideally, yes; practically and theoretically, no. An ideal analysis would be a complete analysis—it would tell us just how much of everything the metal contains. Actually, such analyses cannot be obtained. It is very difficult to get representative samples, and it would cost too much to determine the exact amounts of some elements that are present in amounts of a few hundredths of one per cent. Cast iron may contain a few hundredths per cent of such elements as copper, nickel, cobalt, or even silver or gold, and possibly also of oxygen, nitrogen or others. Presumably, the effects of the traces of these elements can for the most part be neglected, but we cannot be sure about this for any particular element until it has been investigated by competent workers. We certainly cannot predict the properties of an alloy from its analysis unless we have a complete analysis, or know the analysis to be sufficiently complete to permit of its determining all the properties desired to be known. Analyses, as usually made, even those called complete analyses, are not ideally complete. Therefore we certainly cannot predict the properties of pig iron from the analyses usually available.

From time to time circumstances arise which cause one or another of these details to be investigated carefully, and it is known that the effects of very small amounts of many of the elements, such as copper and nickel, etc., are so slight as to be negligible for practical purposes. While many of these are negligible, it is by no means sure that all of them are. In fact, within a few years a very good case has been made out tending to prove that the effects of a few hundredths of a per cent of oxygen is of very great importance in determining the properties of cast iron. The late J. E. Johnson, Jr., did a great deal of careful work on this and reported his results in a very convincing manner. It is hard to understand how it is possible for oxygen to exist at a high temperature in composition in an alloy that contains so many elements that ordinarily combine energetically with oxygen. The exact form of the oxygen was not determined in Johnson's research, neither was the effect quantitatively determined. It was found that iron with any small per cent of oxygen within limits would have certain valuable properties, and iron otherwise, as far as determined, identically alike, but having no oxygen, did not have those properties and was not so good.

When a small amount, up to 18 per cent by weight, of silicon alloys with pure iron the compound Fe_2Si is formed, and this compound then exists in solid solution in the alloy. The properties of this solid solution alloy of iron and silicon are somewhat different from the properties of pure iron. The electrical resistance and magnetic permeability are increased, the magnetic relativity decreased, and the crystallization of the metal is made coarser. The alloy is not able to dissolve as much carbon as can the pure iron. The alloy is much more resistant to the ordinary acids than is pure iron, and this property is made use of in a number of special acid resisting casting compositions high in silicon which have been developed. These castings are usually very hard

and very brittle. But a factor that has a certain action on pure iron may or may not have just the same action on iron when some other element is present; and each added element complicates the situation in the number of possible actions it may exert in view of varying composition.

For irons as used in ordinary gray iron, or in malleable, foundry work, the more important effect of silicon is its influence on the condition of the carbon. Carbon may be present in cast iron either as graphite, or as the compound Fe_3C . Graphite is a soft, black substance with a strong tendency to crystallize in leaves or plates when conditions permit. It is itself weak and non-adherent to iron, and it therefore affects the strength of the metal according to how much it breaks up the continuity, and this depends on the shape, arrangement and size of the particles of graphite. And the shape and size of graphite particles can vary very widely from globular particles of a diameter less than a hundredth of an inch, to plates an inch or more in extent, along which the metal cleaves with little effort. Any influence which tends to control the shape and size of graphite particles will be of great importance to foundry men, and this is what J. E. Johnson, Jr., claimed for oxygen, namely, that the presence of a small amount of oxygen caused the graphite to be present in small, scattered particles which break up the continuity of the iron much less than the coarse plates formed in the ordinary run of foundry gray iron. He stated even that the presence or absence of silicon, phosphorus and manganese will not account for half of the facts which have long been known concerning the control of the carbon condition, fluidity and chilling qualities of the iron.

Silicon has a strong effect which varies with temperature and the amount of silicon present, tending to force carbon into the form of graphite, this tendency being stronger the higher the temperature. The tendency is so slight at temperatures below the pearlite transformation point that it is not usually effective except in the presence of a catalyzing agent, such as graphite already formed at a high temperature. In the case of iron alloys rich in carbon, i. e., cast irons, silicon seems to act to lessen the total amount of carbon the metal is capable of absorbing. According to Hatfield some 3.25 per cent of silicon will reduce the carbon in iron from about 4.3 per cent to about 3.4 per cent, and 25 per cent of silicon further reduces the carbon to about 1 per cent. The presence of the silicon raises the freezing point of the eutectic from about 1135 deg. C. for pure iron to 1190 deg. C. for the 3.25 per cent silicon alloy and to some 1250 for the 25 per cent alloy. In spite of the higher melting point of the silicon containing alloys they are very fluid when melted, and this effect is one of the practical points in the use of silicon in commercial amounts.

It is not known that the silicon has any particular effect to control the shape of the graphite; it merely tends to change the carbon from the form of the compound Fe_3C to the form graphite. The thing that mainly controls the shape of the resulting graphite is the temperature at which the change has been forced in any particular case, and it may be that oxygen also has a very important influence on these factors, though the way in which this influence is exerted is not yet exactly known.

But the control of carbon as between graphite and combined carbon does not tell the whole story. As Fe_3C , carbon may exist in iron in different ways, and the treatments under which silicon is active are also treatments which affect the Fe_3C , entirely aside from the way it is affected by the silicon present. The combined carbon

may exist in iron as a part of the constituent called pearlite which is composed of very minute alternating leaves or plates of iron and of this compound Fe_3C ; and it may also exist as a separate constituent by itself in a more or less massive crystalline form, when it is often spoken of as free cementite. On heating iron past a temperature of about 700 deg. C. the pearlite undergoes a change, and its constituents, iron and carbide, merge or dissolve in one another and form a new constituent, called Austenite, which is the normal form of the alloy at high temperatures. The iron in this solid solution is in a different condition from the iron in the pearlite, a different allotropic modification with different crystal form and different other properties. As the temperature rises above 700 deg. C. to about 1130 deg. C. this Austenite is capable of dissolving increasing amounts of carbon as Fe_3C up to about 1.7 per cent of carbon at 1130 deg. C. If more carbon is present at any temperature than the Austenite can dissolve it is probable that it is this excess carbon not in solid solution that is first affected by the silicon present at the high temperature and caused to break down from the compound form into graphite. Furthermore, there is the possibility that the carbide that exists in solid solution in the Austenite may be, to a certain extent, dissociated into ions, or some similar form, in a manner analogous to electrolytes in water solution, and that the carbon containing ion may be more susceptible to the action of silicon than the carbon of the carbide in solid solution and not dissociated. Since in some cases all of the carbon in cast iron exists as graphite it is quite possible that the silicon can force the change also of the carbon that is dissolved in the Austenite, although the last portions of the carbide to be broken down may be changed at a temperature below the pearlite transformation.

If, at a very high temperature, in the solidification of a molten iron, carbide be crystallized out, the tendency of any silicon present to change this into graphite and iron is very strong. Grey iron is formed when the tendency is just strong enough to cause the graphite to form while the iron is in a plastic, but not fluid condition. Graphite that forms while the iron is still thoroughly fluid will naturally rise to the surface and float away as kish, although often some of the kish is caught near the surface in the iron in masses. Since in gray iron the graphite exists for the most part in idiomorphic crystals, well scattered through the metal, the condition of the metal when they formed is thus fairly definitely established. If the graphite is formed after the iron has completely solidified it must come out in the forms that are characteristic of malleable castings, rather than the idiomorphic leaves, etc., in which it occurs in gray iron.

It was stated that in pure silicon alloys the silicon exists as the compound Fe_2Si in solid solution in the iron. But cast iron is a complex alloy and we need to consider not the iron and silicon alone, but also carbon, manganese, sulphur and phosphorus also, and how these added elements affect the alloys. When carbon only is present in addition to silicon and iron, the carbon exists as above outlined, and the silicon exists mainly in the ferrite or pure iron part of the alloy in solid solution, while a smaller portion of the silicon is crystallized with the carbide Fe_3C , and it is quite likely that it is the small amount of silicon so crystallized that lessens the stability of the carbide so much.

Professor Albert Sauveur, of Harvard University, has very ably presented the idea of the importance of the proximate composition of alloys, especially iron and steel. The term proximate composition or proximate

analysis must not be confused with the similar sounding word approximate. Proximate analysis means analyzing into the physically separate entities or smallest particles we can distinguish by purely physical means which go to make up the alloy. These entities have been named by Professor Howe "metarals." Cast iron is made up of the metarals, ferrite, pearlite, cementite or free cementite, graphite, sulphides, Steadite or the iron phosphide eutectic, and others according to its ultimate composition. Each metaral may be an element, or a compound, or possibly a mechanical mixture such as an eutectoid alloy. The metarals are the separate things seen when the sample is properly prepared and examined by the aid of the microscope, and occasionally some of the metarals may be large enough to be seen without the microscope, though this would be doubtful in any good commercial metal.

Manganese forms solid solution alloys in all proportions with iron. It also forms a carbide of the formula Mn_3C , which is capable of crystallizing with Fe_3C , and in any irons containing much manganese it is probable that a part of the manganese exists in both of these forms. Manganese has a much higher affinity for sulphur than has iron, and whenever something like twice or more than twice as much manganese as sulphur is present most of the sulphur will form either manganese sulphide or complex manganese iron sulphides.

Sulphur forms with iron the compound FeS , which is fairly stable at high temperatures. This sulphide is very detrimental to iron because it forms envelopes about the iron grains, and having itself little strength mechanically and but little cementing quality, it makes what is called a rotten alloy, or one which will crumble easily. This effect is particularly in evidence at a fairly high temperature, about in the rolling temperature for steel, when the iron sulphide is melted or plastic. The manganese sulphide or manganese iron sulphides that form in preference to iron sulphide when sufficient manganese is present behave very differently in iron, partly because of their higher melting point and partly because of the different surface tension between them and iron. The shape of the particles of the manganese bearing sulphides tends to be more bulky than the pure iron sulphide, so the manganese bearing sulphides appear as small round globules, or as these globules may be elongated into strings, not as the extended envelopes that enclose the grains of the metal. Aside from this effect of sulphur, sulphur has a very powerful influence tending to make the carbon remain in the combined form; and in this way sulphur strongly opposes the action of silicon. It may be that it exerts this influence by a part of it being crystallized with the carbon in the carbide and making this compound Fe_3C more stable. It may be even that it combines with some of the silicon that is so crystallized into a compound of sulphur and silicon and so directly neutralizes the effect of the silicon.

Hatfield investigated the influence of sulphur, manganese and silicon upon the precipitation of graphite, and reported that the silicon is present to a certain extent in the carbide, but mostly in the matrix; the manganese is largely found in the carbide to the exclusion of silicon, and the sulphur also appears to cause the exclusion of the silicon from the carbide, though the methods employed failed to find any sulphur in the carbide. Their heat treatment experiments indicate that the presence of these elements modifying the composition of the carbide renders it more or less difficult to dissociate at a given temperature, and altering the composition of the alloy renders it more or less soluble in the Austenite.

thus changing the amount of free carbide to be acted on by any influence. It seems that both manganese and sulphur, each separately, tend to make the carbide more stable, but that to a certain extent they may each neutralize the effect of the other in this direction.

Phosphorus forms the compound Fe_3P , and this alloys with iron, going into solid solution therein with limits, or with iron and carbon forming an eutectic of very fluid character and low melting point, and which may be used when very fluid irons are required that do not need to have great strength. These iron, carbon phosphorus alloys are very interesting. Carbon and phosphorus tend mutually to exclude each other from iron, or each to lessen the amount of the other than the iron can take up. Phosphorus is used in cast iron to a notable extent only in cases where a very fluid iron is needed in order to flow some distance in a thin sheet through a mold, or when an iron is needed which will expand at the moment of solidification and so fill the mold with great exactness even in its finest detail as in some art castings. This iron with high phosphorus is very brittle, but is still strong enough for many uses.

The effect of silicon can be explained by explaining its effect on the proximate composition of the cast iron. To do this let us first make a rough statement of what the metarals in cast iron are. We may begin with the manganese and phosphorus. Some manganese first unites with all of the sulphur present to form MnS , or with some iron and all of the sulphur to form mixtures of MnS and FeS . What manganese is left over from this is divided, part of it forming Mn_3C and crystallizing with the Fe_3C and the rest going into solid solution in the ferrite. The phosphorus forms Fe_3P and this forms with ferrite an eutectic alloy; in cast iron but very little phosphorus remains in solid solution in the ferrite. The carbon is present as pearlite, or pearlite and cementite, and graphite, according to the total carbon, and the silicon and heat treatment to which the metal has been subjected. The effect of the silicon both in the ferrite and in the cementite has been outlined above.

Moldenke and West and others have made experiments to determine the relative melting temperature of white and of gray iron, and showed that the white iron melts at a lower temperature than the gray, and melts in about the same fashion as ice, whereas gray iron goes through a mushy stage in melting. Irons with high combined carbon were found to melt at about 1100 deg. C., while those with but little combined carbon and mostly graphite melted at about 1230 deg. C. Grey iron melted at about 110 deg. C. lower temperature than steel with the same amount of combined carbon. These facts are of obvious interest in regard to the arrangement of charging iron of various kinds in a cupola furnace.

The shrinkage of cast iron is the contraction of the liquid iron in cooling from the pouring temperature to the setting point, together with any contraction that may occur in actual setting or freezing. In other words, it is the amount that would have to be added of liquid iron to secure a thoroughly sound casting after the mold is first just filled. The difference in size between pattern and finished casting is properly termed contraction. Most of the difference between different irons in regard to this contraction from pattern to cold casting seems to correspond to the distribution of carbon as between the combined and graphitic forms. When all or nearly all of the carbon is in the graphitic form the contraction amounts to about $\frac{1}{8}$ in. to linear foot; when all the carbon is combined, to about $\frac{1}{4}$ in. to the foot. It is reason-

able to suppose, therefore, that the volume occupied by the carbon as graphite is about the equivalent of $\frac{1}{8}$ in. to the foot. In actual volume this works out about as follows: a pattern containing 100 cu. in. will yield a gray iron casting containing very nearly 97 cu. in., or a white iron casting of 94 cu. in. The white iron casting on being well annealed will expand again to 97 cu. in.

As silicon is one of the chief agencies by which the condition of the carbon may be controlled, it will be seen that the relationship between silicon and shrinkage and contraction are very close. The quantities of manganese and sulphur are also very important. It is interesting to note that in the formation of graphite the increase of bulk must take place against the resistance of the metal, and that the metal is actually expanded by an amount corresponding to the increase. Each spot of graphite has had to open up space enough for itself by stretching the iron surrounding it; and it is probable that this pressure is one of the large factors in control of carbon condition in castings. The actual working of the metal matrix thus caused is very slight, and takes place at a high enough temperature so that its effect is overcome by self annealing.

PITTSBURGH TO ENTERTAIN CHEMICAL SOCIETY

Pittsburgh will be the host of the American Chemical Society at its Annual Fall meeting, from September 4th to September 9th, inclusive. All of the divisional meetings will be held at the Carnegie Institute of Technology, while the general meetings are scheduled at Carnegie Music Hall.

An exceptional program has been outlined for the entire week, with a variety of social events for the Councillors and their wives.

Of outstanding importance in the program will be an address by Thomas Midgley, Jr., of the General Motors Research Corporation on "Chemical Control of Gaseous Detonation with Particular Reference to the Internal Combustion Engine." Mr. Midgley will be assisted by T. A. Boyd. The lecture will include demonstrations of normal combustion and detonation in glass tubes, the suppression of detonation by the addition of certain chemical compounds, and demonstrations with an internal combustion engine motor containing quartz windows and apparatus for measuring radiation. The motor will be operated on detonating and non-detonating fuels. Lantern slides will be shown illustrating the periodic variation of anti-knock value among the 16 elements. Blueprints of the paper will be issued at the meeting.

"Pittsburgh as a Chemical Manufacturing Center" is the subject of an address to be given by Dr. J. H. James, Head of the Department of Commercial Engineering, and Dr. W. F. Rittman, Head of the Department of Commercial Engineering, of Carnegie Institute of Technology. Dr. James will discuss "Pittsburgh's Raw Materials and Markets for Chemical Products." Dr. Rittman will speak on "Pittsburgh's Transportation and Financial Advantages."

By special arrangements, the Committee of the Pittsburgh Section of the A. C. S. has obtained dormitory privileges for the Councillors at Carnegie Tech during the Meeting. The Men's Dormitories will be opened to house 350. One of the Women's Dormitories has been offered for the use of Councillor's wives.

Heat Transmission in the Hot-Galvanizing Process

Describing the Thermal Features of the Process—The Rate of Motion of the Sheets Through the Bath Should Vary With the Sheet Thickness If Based on the Factor of Heat Transmission.

By J. D. KELLER

ALTHOUGH the hot galvanizing of iron and steel sheets is an old and well-known process, very little study seems to have been given to the conditions of heat transmission occurring in it. The rates at which sheets of various thicknesses should be passed through the zinc bath have had to be determined simply by trial and re-trial, the controlling factors being little understood. In the present article an attempt will be made to make clear the thermal features of the process, and to see how, if based on the important factor of heat transmission, the rate of motion of the sheets through the bath should vary with the sheet thickness.

And first it will be well to consider the mechanical or physical actions occurring in the galvanizing bath. Referring to the diagrammatic sketch, Fig. 1, the steel sheet, fresh and clean from the pickling process, passes through the first pair of rolls, and through the flux box at (A), enters the molten zinc at (B), passes

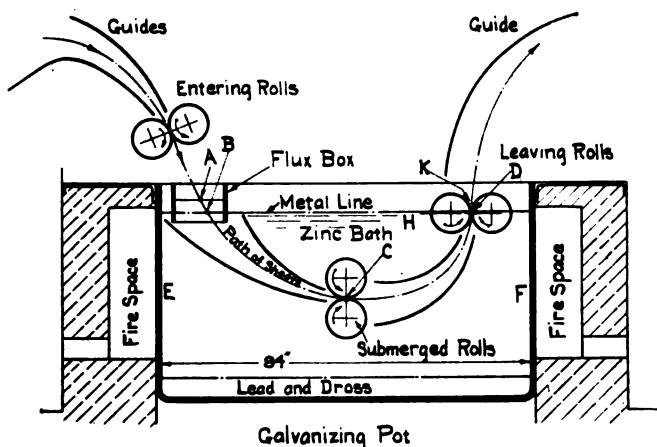


Fig. 1—Diagrammatic sketch of galvanizing machine.

through the bath to the submerged rolls at (C) and thence is directed by the guides to the third set of rolls at (D). By them it is drawn out and sent on to the conveyor. Heat must not be imparted to the bath from the bottom of the pot, because the dross and lead would thereby be stirred up and would contaminate the zinc. Fire spaces are provided at the ends of the pot, and sometimes also at the sides.

It is very important to note that the bath is continually and quite violently agitated by the motion of the rollers, and of the gears and mechanism which drive them. This is made evident by the "wash" or churning up of the bath, near (B) in particular. The agitation produces most excellent heat transmission

through the molten zinc (by means of convection currents), and carries the heat from (E) and (F) to the sheets with very little drop in temperature. It also provides for thorough mixing of the different portions of the molten metal. The zinc at (H) receives no heat during the time in which a sheet is passing between it and surfaces (E) or (F), but during the intervals between passages of the separate sheets, its supply of heat is replenished by mixing with zinc from other parts of the bath.

At some point in the passage of the sheet, the rising temperature of its surface reaches the fusion temperature of zinc, and the formation of the zinc-iron alloy, which cements the zinc coating to the sheet, can then begin.*

From the theory of heat conduction it is known that when two substances are in very perfect contact, no "temperature drop" should occur across the contact surface. Careful temperature measurements at such contacts—for instance, the contact of polished flat metal surfaces, or that of a liquid or plastic material with a solid,—have shown that in fact no temperature drop exists there. Where a temperature drop appears to exist, this in reality means a steep temperature gradient in a layer or film of some substance, such as air, which has a high resistance to the flow of heat.

This naturally brings up the question, how can the liquid zinc come in contact with the cold steel surface and still remain molten? The answer is that it does not do so; an infinitesimally thin film of solid zinc forms instantly on the surface of the sheet; the film thickens, at first very quickly, then more and more slowly. Finally it reaches a maximum thickness, then starts to melt off. The melting progresses with increasing rapidity until the solid film entirely disappears, and the liquid zinc comes in contact with the steel surface.

As shown in the diagram of Fig. 2 (in which thicknesses are much exaggerated), there is, first, the steel sheet itself (1); then a layer of solid zinc (2), varying in thickness as time goes on; next a layer or film of more or less stagnant liquid zinc (3); and beyond this the main body (4) of the zinc bath, in violent agitation.

Just here it must be remarked that between (1)

*It is stated that the zinc powder which is used in the dry galvanizing or Sherardizing process begins alloying with the steel or iron surface at a temperature 200 deg. lower than the melting point of zinc. On the other hand, it is stated that the fusion point of the zinc-iron alloy formed in hot galvanized coatings is noticeably higher than that of pure zinc. In any case, the alloying during hot galvanizing would not begin until the film of solid zinc, referred to further on, had disappeared.

and (2) there may possibly exist a slight film of flux; but in any case this would be so thin that the heat transmission would be very little affected. Also, it should be mentioned that when the sheet enters at (A), Fig. 1, there is a thin film of water adhering to its sides. Any part of this water which is not absorbed by the flux between (A) and (B) will be evaporated shortly after entering the zinc bath.

The film (3) of Fig. 2 is not to be considered as a sharply defined layer. As the steel sheet with its adhering layer of solid zinc passes rapidly through the bath, it drags some of the liquid along with it. Thus the particles near surface (5) have very little motion relative to the sheet. From (5) to (6) the relative speed of motion rapidly increases. Rate of heat transmission is greatly influenced by the rapidity of this relative motion.

Permissible Speed of Travel of Sheets Through Bath.

As will be shown in the second part of this article, the heat distribution in thin sheets is so nearly uniform throughout, at the instant when the solid zinc has just disappeared, that the center can never be as much as one-half degree below the surface temperature; probably it will be only a few tenths degree below it.

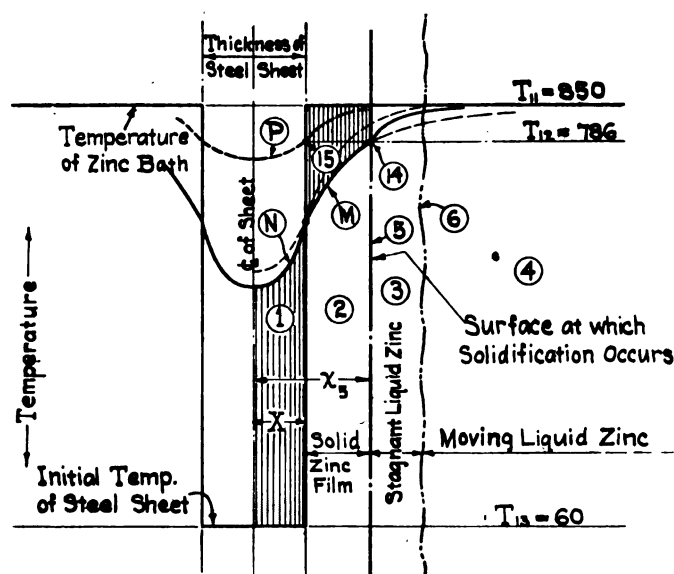


Fig. 2—Conditions during galvanizing.

This conclusion makes the calculation of heating time a very simple matter. Taking the temperature of the sheet as constant throughout would mean an error of less than 1/20 per cent. The heat absorbed by the sheet, from the starting time until the solid film has disappeared, is $w_1 \cdot c_1 (T_{12} - T_{13}) \cdot 2X$, per square foot of sheet.

$$\text{Heating time} = \frac{w_1 \cdot c_1 (T_{12} - T_{13}) \cdot 2X}{2k \cdot (T_{11} - T_{12})}$$

where w_1 is density of the steel = 488 pounds per cu. ft.; c_1 is specific heat of the steel, for the temperature range from 60. to 786. deg. F., = 0.133; $T_{11} = 850$, $T_{12} = 786$, and $T_{13} = 60$. deg. F., see Fig. 2; X is one-half the thickness of the sheet, ft., and k is heat transmission coefficient, Btu per sq. ft., hour and deg. F. For No. 24 gage sheets and for $k = 400$, time = 0.00192 hour = 6.9 seconds.

Taking the length of path through the molten zinc as 5.8 ft., and the speed for No. 24 gage sheets as 35 ft.

per minute, the time during which each portion of the sheet is passing through the bath is 10. seconds. From the previous figures, the time required for the surface film of spelter to melt off is 6.9 sec., if k is 400 Btu per sq. ft., hour, deg. F. The corresponding distance of travel is 4.0 ft. During the remainder of the time, the sheet is heated above the zinc fusion temperature. The time during which the alloying action can take place is much longer than this, because the zinc coating remains liquid after the sheet has left the bath, until all of the latent heat has been emitted to the surrounding air. The solidification of the coating requires appreciable time, since the rate of emission to the air averages only about 4. Btu per sq. ft., hr., deg. F.

If the rate of heat transfer in the bath were constant, the time required would be directly proportional to the thickness of the sheet, and the speed of travel would be inversely proportional to the thickness. But k varies markedly with speed of motion of the sheet relative to the liquid. No test results are available for the heat transmission coefficient from liquid zinc, but when the coefficient is estimated from operating data, it appears that at the speed of 35. ft. per min. k is about 400., while for hand dipping (very small velocity), k seems to be about 80. Btu per sq. ft., hour and deg. F. By analogy with heat transmission from gases or other fluids to metal walls, k should increase in direct proportion to the speed of motion, varying about as shown by the expression

$$K = 80. + 9. v$$

where v is velocity of motion of the sheet through the bath, ft./min.

Now if sheets of different thicknesses are galvanized in a given size of pot, and if the solid zinc layer is to be melted off in the same distance of travel, the following relations would hold true:

$$\begin{aligned} \text{density} \times \text{sp. heat} \times \text{temp. rise} \times \text{thickness} \\ 488 \times 0.133 \times 726 \times b/12 = \\ \text{area} \times \text{temp. diff.} \times \text{coefficient} \times \text{time} \\ 2 \times 64 \times (80 + 9. V) \times t \\ t = \frac{4.0 \text{ ft.}}{60. v} \text{ hours.} \end{aligned}$$

$$V = \frac{8.80}{50. b - 1}, b > 0.020 \quad \dots \dots \dots (1)$$

The speeds corresponding to various gages and thicknesses, calculated from equation (1), are shown in the following tabulation:

Gage.	Thickness, inches.	Greatest permissible speed of travel, feet per minute.	Time for surface to reach galvanizing temperature, seconds.
24	0.025	35.0	6.9
22	0.0312	15.6	16.
20	0.0375	10.0	24.
18	0.050	5.9	41.
16	0.0625	4.1	60.

For sheets thinner than 0.02 inch, the velocity would be limited by other than thermal considerations.

As previously stated, the data on rate of heat transfer from the zinc bath are extremely incomplete. In the absence of reliable test results, the coefficients given are the best available.

If the rate of heat transfer were the only factor to be considered, it could be increased by maintaining

a hotter bath and greater temperature difference; although, as zinc vaporizes at about 930. deg. F., the gain in this direction is sharply limited. But in any case, there is a factor of even greater importance than speed of galvanizing, namely the production of a coating of just the right thickness. The latter depends very largely upon the viscosity of the liquid, and upon the speed at which the sheet is drawn out of the bath. Definite figures as to viscosity of liquid zinc or its variation with temperature are not obtainable, but beyond question it, in common with mercury and most other liquids, becomes less viscous as the temperature is increased. In other words, raising the temperature of the bath tends to produce a thinner coating. On the contrary, increasing the speed tends to give a thicker coating, for two reasons: First, the shearing forces acting to thin down the liquid zinc film on the sheet, as it leaves the bath, are practically constant in magnitude, whereas the time interval in which they can act, decreases as the speed is raised. This effect, which is well known in galvanizing practice, can be demonstrated very clearly by simple and even crude experiments with other viscous liquids such as syrup or heavy oils. Second, the determining viscosity is not that of the main body of the bath, but that of the liquid very near to the sheet surface. After the solid film has melted off, as previously described, the temperature of the sheet, and of the zinc in immediate contact with it, steadily approaches that of the main

body of the bath. But if the sheet is relatively thick and the velocity high, the temperature may not have risen much above the fusion point by the time the sheet reaches the exit rolls (D), Fig. 1. Thus, in spite of the high temperature of the bath, the zinc near the sheet surface, when drawn into these rolls, may be quite viscous, producing a thick coating.

The thickness can be varied independently by other means. Increasing the pressure exerted by the rolls (D) on the sheet, or rather on the liquid film which is carried between the rolls by viscous drag, thins the coating. By providing grooves which carry a small quantity of the liquid up between the rolls to the space (K), Fig. 1, the thickness of coating is increased, to an extent depending upon the size of grooves and quantity of liquid which they transfer.

In spite of these other means of control, viscosity and therefore temperature plays an important part, especially in coating the thicker gases. For instance, if No. 18 gr. sheet is passed through the bath at 15 ft. per minute, it will have reached the fusion point of zinc only a few inches below rolls (D). The zinc film on its surface will be only slightly hotter, corresponding to the steep part of the temperature-viscosity curve, where a few degrees change makes a tremendous difference in the viscosity. Under such conditions, uniform thickness of coating could not be maintained.

Sheet Steel Rolling and Heating

Discussion Written on "Possibility of Improved Methods of Rolling Sheet Steel," Which Appeared in a Recent Issue of The Blast Furnace and Steel Plant.

By EVAN LLEWELLEN

THE technique of the art, like the early history of iron making, being involved in more or less obscurity, the writer, with an experience of 40 years and through a close association with the older ones possessing an intimate knowledge of what transpired during a few years prior to that, wishes to offer a few remarks in answer to Mr. Sumner B. Ely's candid acknowledgement that but little is known about the work, as appeared in THE BLAST FURNACE AND STEEL PLANT magazine, where he discussed the "Possibility of Improved Methods of Rolling Sheet Steel," leaving it to the judgment of Mr. Ely and others as to whether this will or will not add to the difficulties of the continuous method of rolling light gauge sheets.

It is common today to smile when we hear about the seven to 10-ton housings, the 20-inch rolls and the old steamboat engines used to pull such mills, but it is unwise to imagine that any crudeness existed in the rolling and heating of that period, for a very fine product was being turned out in black, galvanized and high finished sheets, so that in point of quality we have progressed little if any in the last 50 years at least.

Great progress has been made in the way of increasing the weight of the housings and the diameter of the rolls in order to meet the demand for increased output,

in the strength of the machinery enabling the workmen to dispense with almost half the number of passes formerly used in drawing the sheets out to the required lengths, especially with steel of a composition calculated to stand a rather high heating temperature, carbon and phosphorus being used in the right proportions for this purpose, and to prevent welding together of the sheets while being rolled in packs.

However, in order that the operation will be successful, a uniformity of heating must obtain so that all of the sheets will draw out alike, thus not breaking up the thin coating of magnetic oxide formed by the initial heating and rolling and which is firmly adherent to the sheet; for the sheets will weld together where the bare metal surfaces meet; but the fact that a high temperature can be used better guarantees a balanced furnace temperature.

But it is the same with light sheets as with any other steel or iron product—the higher the heating and finishing temperature and the smaller the amount of working which the steel receives the larger will be the grain size, so that while this may secure a larger production the sheets are of indifferent quality, though suitable for many purposes.

Along with such a product there is a growing demand for smooth surfaced sheets calculated to stand stamping

into all conceivable shapes, necessitating a composition that is almost free from hardening elements. Thus, insofar as heating requirements are concerned, we are getting back to the days of refined iron which required a very low heating temperature.

Contrary to present-day opinion of sheet workers, the rolling, and particularly the heating of sheets, had been reduced to a fine art by that time, the intricacies of the method being kept shrouded in an air of mystery with the tendency for the jobs to descend from father to son or some favored friend, thus retarding the advancement of other and perhaps more progressive young men. In the accomplishment of its purpose this attitude was necessarily short lived, since any bright man had but to copy the tactics employed in manipulating the fire, there being no necessity for him to understand the chemistry involved in the process of gas-firing, which was the method employed when burning coal.

Because of its large heating chamber the sheet furnace is peculiarly adapted to this method of firing when a very low temperature is desired, the upper portion acting as a holder in which the gases become thoroughly mixed, leaving ample room below for combustion. This makes for a balanced temperature, and the atmosphere must not be confounded with that of a muffled furnace, for while the damper is raised there is a well regulated flow of air up through the fire, the raising or lowering of the damper making the possibilities of control quite definite and easy.

Great importance was attached to the compactness of the fuel bed, the idea being to avoid any local high temperature and the letting in of free oxygen (together with undecomposed carbon dioxide) which condition not only unbalances the temperature, but destroys the mildness of the furnace atmosphere.

Considerable open-furnace annealing was practiced in the early days, necessitating a strict avoidance of any oxidizing elements coming in touch with the metal. In fact, oxidizing elements have no place in the sheet-furnace at any time since oxygen with carbon dioxide freely enters between the sheets while they are as yet cold and just as soon as the bundle or pack of sheets begins to absorb heat the carbon dioxide, in the writers' opinion, decomposes into its constituent parts and the oxygen combines with the metal in the formation of a loose spongy scale which emits a smouldering gas. This chemical reaction seems to be exothermic and effervescent, its intensity depending upon the temperature of the pack and the friction of rolling as is evidenced by the variations in the expansion of the enclosed gas in causing separation of the sheets and the appearance of the scale upon the interior surfaces of the sheets after rolling.

Steel expands with heating, leaving the pores open to absorb deleterious gases with the usual hardening effect noticeable with light sheets in that they do not settle together in proper cohesion necessary to exclude the but partially burned gases with which the heater surrounds the packs in an attempt at soaking shortly before finishing, therefore the old Welsh trick of checking further calorific power by dropping the damper and allowing the absorbed heat to become thoroughly diffused throughout the pack is not practical in an oxidizing atmosphere, and annealing is entirely out of the question.

With the introduction of natural gas into the mills of the Pittsburgh district many years ago, many and varied types of combustion chambers were brought out. Only one of these proved to be the acme of perfection in the production of a continuous and unfailing non-

oxidizing atmosphere, but the principles underlying the method of operation were not generally understood and so it was not picked out and standardized.

The present standards of rear chamber construction and operation seem to be at variance with these older ideas insofar as the volume, temperature and composition of the gases are concerned and the point in the furnace where the actual combustion takes place. As to the different fuels used, their relationship is fixed by physical law so that all failures can be ascribed to a non-observance of these simple scientific facts which the early Welshmen tried to conceal from the Yankee. It is evident that these principles had been thoroughly and scientifically analyzed before the business was introduced into this country.

ELEVENTH ANNUAL SAFETY CONGRESS

The program of the Eleventh Annual Safety Congress of the National Safety Council at Detroit, August 28 to September 1 is now complete. On July 15, a printed copy of the entire week's sessions, together with a formal invitation from the Detroit Safety Council and supplemented by a personal letter from President Arthur H. Young, calling attention to the points of greatest interest during the five-day program will be sent to 15,000 executives and safety men representing supervision over six million and more workers in the United States and Canada.

Indications now are that the 1922 Safety Convention will be the largest and most complete in the history of the National Safety Council. Never before in the history of the organization has response to invitations to participate in the Annual Safety Congress been so spontaneous. Public officials, industrial executives, well known authorities in research, science and education, have volunteered to appear on the programs to do their bit for national safety.

The first day's program may be taken as a criterion for the quality of each and every meeting during the week. On this day a short business meeting will precede, in the morning, talks by Edgar A. Guest of the Detroit Free Press, Judge C. L. Bartlett of the Detroit Court of Records, and an address of welcome by President Samuel C. Mumford of the Detroit Safety Council, and others. In the afternoon Dr. John Wesley Hill, Chancellor, Lincoln Memorial University and author of "Abraham Lincoln—Man of God," R. M. Little, Director of Rehabilitation, New York State Department of Education; A. H. Lichty, Vice-President, the Colorado Fuel & Iron Company and Dr. J. J. Tigert, Commissioner of the U. S. Bureau of Education, will speak on four important aspects of national safety—Educational, industrial, public, and national safety. A feature of this program will be an excellent presentation dramatizing the subject suggested by a recent Council bulletin entitled "Was Daddy Hurt Much?"

Complete discussion of the various phases of industrial and public safety will be had at the meetings of the twenty different sections into which the Council's activities are divided. These meetings will cover safety problems in the automotive, cement, chemical, construction, metals, paper and pulp, packers and tanners, rubber, textile, woodworking, electric railway, public utilities, steam railroads, mining, public safety, educational, engineering, drop forge, health service and women in industry divisions.

Centrifugal Casting

Giving the Benefits of Making Centrifugal Castings in Vertical Molds Rather Than in Horizontal Molds As Is Customary—
Theoretical Calculations Necessary for Method Are Given.

By N. LILIENBERG*

ALTHOUGH the casting of metals hollow by centrifugal force in rotating molds has been practiced a long time in a limited scale it is only within the latest years that it has developed into important production. The object is well known to be saving of expense, avoiding casting over core and obtaining liquid compression.

The cores are especially objectionable in casting low carbon steel which shrinks about the double of cast iron or semisteel and therefore is liable to produce surface cracks.

The compression by centrifugal force can be increased beyond the strength of material evidenced by the occasional bursting of heavy rims of flywheels and by the especially strong steel needed for milk-separators.

The centrifugal force is: $C = \frac{m \cdot v^2}{r}$, in which

m = the mass = $\frac{w}{g}$, w = the weight, g = the acceleration of gravity = 32.2', r = the radius, v = the circumferential velocity = $\frac{\pi \cdot r \cdot n}{30}$, n = number of revolutions per minute, π = 3.1415.

If one cubic inch of steel weight about 0.26 lbs. is rotated on a radius of 6 in. at 500 revolutions per minute:

$$C = \frac{0.26}{32.2} \times \frac{\pi \cdot 500 \cdot 0.50^2}{0.50} = 11 \text{ lbs.}$$

and if the speed is increased to 1,000 rpm the strain on the tie to the center will be 44 lbs. exerted by only 1 cubic inch.

As far as I know centrifugal castings in quantities have been made only in horizontal molds. It is more simple in operation and construction to cast in vertical molds whereof I have been convinced by experiments and calculations.

It is in order to first give the theoretical calculations.

1. The Centrifugal Parabola.

That a rotating liquid forms a hollow, shaped as a paraboloid, can be demonstrated as follows: In Fig. 1 the letters represent the above named quantities and in addition dY = the differential of Y and dX = that of X .

*The author is a consulting engineer on the manufacture of centrifugal steel castings, located at 283 Rochelle Ave., Philadelphia, Pa.

$$C = \frac{\pi^2}{g \cdot 30^2} \cdot n^2 \cdot \frac{X^2 \cdot w}{X}$$

For convenience I call $K = \frac{\pi^2}{g \cdot 30^2}$

$$C = K \cdot n^2 \cdot X \cdot w$$

As the liquid places itself at 90 degrees towards the resultant of the centrifugal force and the weight of each particle

$$C \cdot \tan a = w; K \cdot n^2 \cdot X \cdot \tan a \cdot w = w;$$

The tangent of the curve forms the same angle a with the vertical:

$$dY \cdot \tan a = dX; \tan a = \frac{dX}{dY}; K \cdot n^2 \cdot X \cdot \frac{dX}{dY} = 1.$$

By integration:

$$K \cdot n^2 \int X \cdot dX = \int dY; \frac{K \cdot n^2}{2} \cdot X^2 = Y,$$

which is the equation of a parabola.

Fig. 2 shows how rapidly the length of the parabola increases with the speed forming practically straight lines with small differences in diameters in the part cut off in the mold.

2. Calculating the Volume of the Liquid and the Speed, to Produce Determined Results. Fig. 3.

The volume of a paraboloid is $\frac{1}{2}$ of the circumscribed cylinder.

It is evident that the volumes excavated below the line of rest, and raised above it as indicated by the shaded parts in Fig. 3 shall be equal that is: $V_1 = V_{11}$, which means

$$\frac{1}{2} \cdot \pi \cdot X^2 \cdot Y_1 = \pi \cdot r^2 \cdot Y_{11} - V_{11}$$

$$\pi r^2 \cdot Y_{11} - \frac{1}{2} \cdot \pi \cdot r^2 \cdot (Y_{11} + Y_1)$$

$$+ \frac{1}{2} \cdot \pi \cdot X^2 \cdot Y_1$$

$$\frac{1}{2} r^2 (Y_{11} + Y_1) = r^2 \cdot Y_{11}; \frac{1}{2} \cdot (Y_{11} + Y_1) = Y_{11};$$

$$Y_1 = Y_{11}.$$

The length of the paraboloid is:

$$Y = \frac{1}{2} \cdot K \cdot n^2 \cdot r^2$$

For a 6 in. mold $r = 0.25'$.

$$\text{With } n = 100; Y = 0.106'$$

$$n = 250; Y = 0.66$$

$$n = 500; Y = 2.65$$

$$n = 750; Y = 5.95$$

$$n = 1000; Y = 10.60 \text{ feet.}$$

I call the line to which the liquid rises without rotation the line of rest. As it has been demonstrated

that this line divides the length of the paraboloid in two equal parts

$$\frac{1}{2} \cdot K \cdot n^2 \cdot r^2 = Y$$

$$\frac{1}{2} \cdot K \cdot n^2 \cdot X^2 = \frac{1}{2} \cdot Y$$

$$X = \sqrt{\frac{Y}{K \cdot n^2}} \cdot r = 0.707 \cdot r$$

All the parabolas, independently of speed therefore intersect the line of rest at a constant distance from the center.

This as well as the equal division of the length hold good as long as the apex stays inside of the mold.

The speed at which the apex touches the bottom of the mold can be calculated as follows, Fig. 3:

$$\frac{1}{2} \cdot K \cdot n^2 \cdot \frac{r^2}{2} h; K = \frac{\pi^2}{g \cdot 30^2}$$

$$n = 108.75 \cdot \frac{\sqrt{h}}{r}$$

When the speed is increased beyond the last named limit, an imaginary paraboloid forms below the bottom of the mold, Fig. 4. The line of rest then no longer divides the length of the parabola in halves.

- V = volume poured in the mold.
- V_1 = the truncated paraboloid.
- V_{11} = cavity over line of rest.
- V_{111} = volume of liquid raised above line of rest.
- V_{1v} = volume of imaginary paraboloid below the bottom.

$$V_{11} + V_1 + V_{1v} = \frac{1}{2} \pi \cdot r^2 (Y_{11} + h + Y_{1v})$$

$$V_1 = V_{11} = \frac{1}{2} V$$

$$V = \pi \cdot r^2 \cdot h;$$

$$V_{1v} = \frac{1}{2} \cdot \pi \cdot X_1^2 \cdot Y_{1v};$$

$$Y_{1v} = \frac{1}{2} \cdot K \cdot n^2 \cdot X_1^2;$$

$$V_{11} + \frac{1}{2} V + \frac{1}{2} \pi \cdot r^2 (h + Y_{1v}) -$$

$$\frac{1}{2} V = \frac{1}{2} \pi r^2 (Y_{11} + h + Y_{1v}),$$

$$V_{11} = \pi \cdot r^2 \cdot Y_{11} - \frac{1}{2} V;$$

$$Y_{11} + h + Y_{1v} = \frac{1}{2} K \cdot n^2 \cdot r^2;$$

$$Y_{1v} = \frac{1}{2} K \cdot n^2 X_1^2$$

$$K = \frac{\pi^2}{g \cdot 30^2}$$

From these equations is obtained:

$$\frac{4 \cdot r^2 \cdot h}{K \cdot n^2} = (X_1^2 - r^2)^2;$$

$$\pm \sqrt{\frac{4 \cdot r^2 \cdot h}{K \cdot n^2}} = X_1^2 - r^2;$$

$$r^2 - \sqrt{\frac{4 \cdot r^2 \cdot h}{K \cdot n^2}} = X_1^2$$

$$\sqrt{r^2 - \frac{2.30}{\pi} \sqrt{g} \cdot \frac{r}{n} \sqrt{h}}$$

$$X_1 = \sqrt{r^2 - 108.75 \cdot \frac{r}{n} \sqrt{h}}$$

This gives the radius of the opening at the bottom of the mold = X_1 . If $X_1 = 0$, that is if the apex just touches the bottom

$$r^2 = 108.75 \cdot \frac{r}{n} \sqrt{h}; n = 108.75 \cdot \frac{\sqrt{h}}{r}$$

which is the same as the above given formula.

For a 6 in. mold, $r = 0.25'$ and if then $h = 1'$, $n = 750$, the radius of the opening at the bottom will be $X_1 = 0.165'$, = about 2" and the thickness of the casting about 1 inch.

To produce a bottom wall thickness of $\frac{1}{2}$ in. the speed would have to be $n = 1,288$. If $h = 0.50'$, $n = 750$, $r = 0.25'$, $X = 0.1,936'$ and the bottom wall thickness = $0.055' = 0.67''$.

When r^2 gets smaller than $108.75 \cdot \frac{r}{n} \sqrt{h}$, the

proposition of course becomes absurd.

If the rising liquid strikes the cover of the mold, a pressure is exerted equal to the weight of the top part thereby cut off and in addition the upward pressure of the same part which turned down gives additional thickness to the walls. All of this can be calculated with the above named formulas. But the deductions are somewhat lengthy to appear in this article.

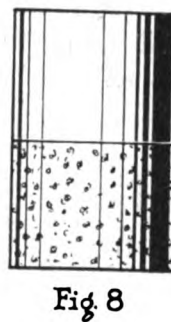
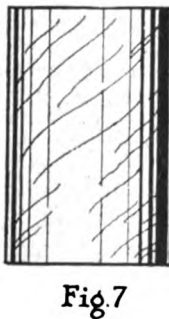
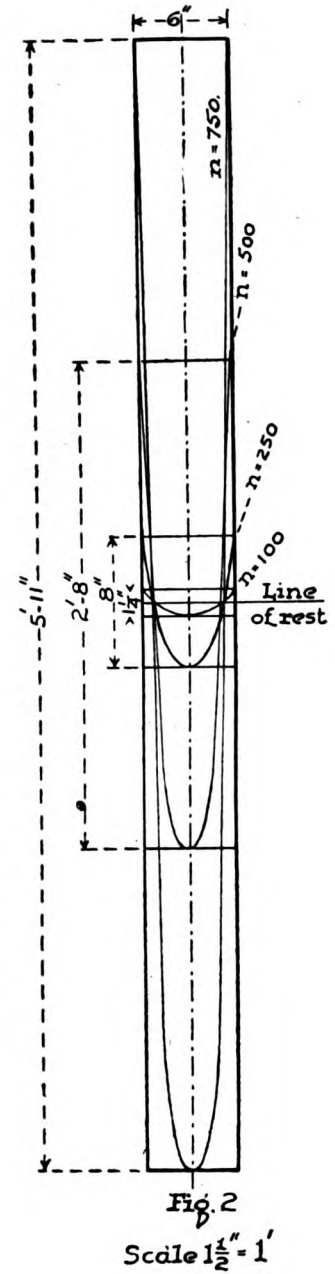
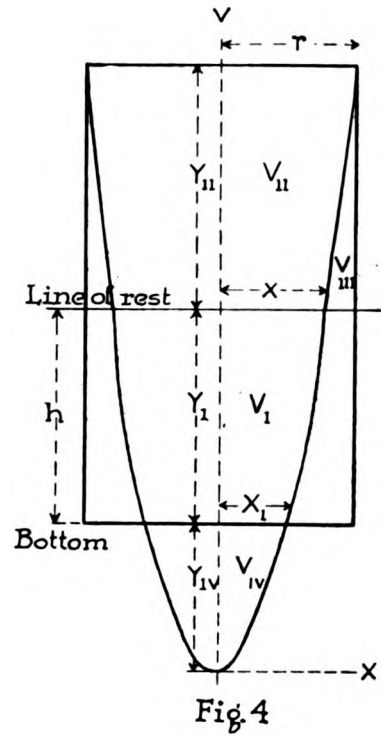
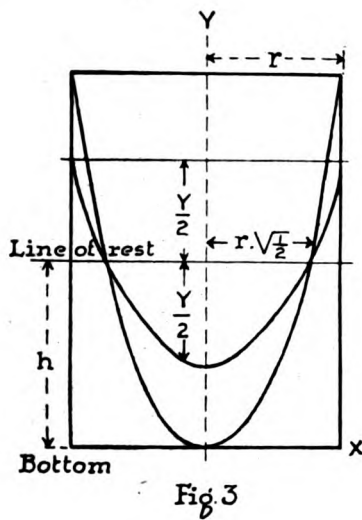
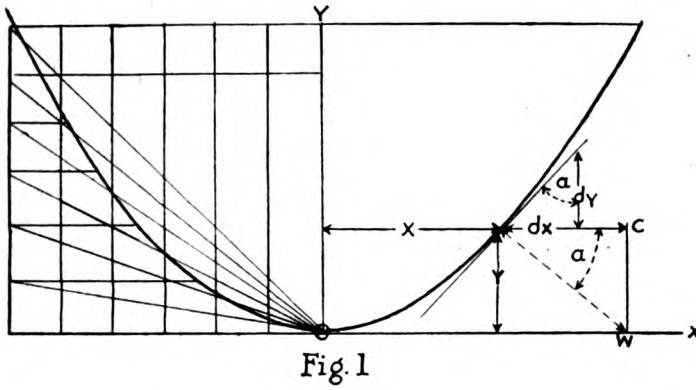
The strength of the mold to resist the pressure can of course be ascertained by calculations which are too well known to be here repeated. With the comparatively moderate speeds used in this process, there is usually no cause for adding any extra strength to the parts in operation.

3. Casting Apparatus. Fig. 5.

The frame is made of two standing round bars of cold rolled steel the lower ends being fixed in a cast-iron bottom plate, the upper ends entering through a cast iron cross piece. The bed plate is securely bolted to a solid foundation and the upper cross piece is held by stay bolts anchored to the walls of the building. The frame must be rigid as the slightest vibrations make the castings defective. A moving shaft is standing in the bottom plate with end thrust on ball bearings. The pulley on the shaft is adjusted according to the motor.

As one motor may drive several machines it is well to have also one idle pulley so that each machine can be stopped separately. The upper end of the shaft moves in a bearing inserted in the cross piece. This as well as the top cross piece are held in place by tubes out to proper lengths and pulled over the bolts. When the nuts on the top are tightened the frame is rigid. The upper end of the driving shaft carries a disk of diameter suitable for the mold and provided with two projecting sectors forming a driving clutch.

The cover of the mold has a hole through which the spout for the pouring enters. This spout which holds the mold in position is fixed in a cross piece made to slide on the tubes surrounding the frame bolts. The strain on this spout is small because the mold



straightens up automatically following the laws of gyration which makes a spinning top stand upright without support. The cross piece containing the spout and funnel for casting is connected by rods to a hydraulic plunger in a cylinder placed on the top. When the casting is finished the spout is lifted up above the mold. This is thus free to be removed as it is standing loose on the rotating platform with only the top of the driving shaft inserted in the center. Another

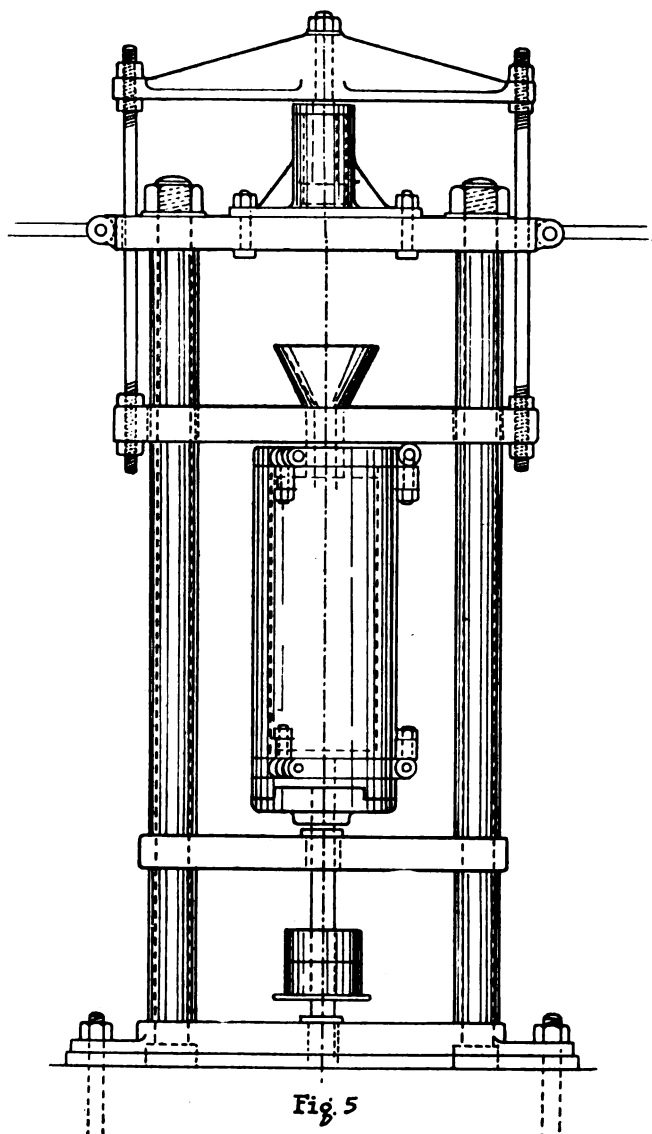


Fig. 5

mold standing close by is then put in its place. This operation only takes a few seconds. The mold will have to be perfectly centered because the least vibrations cause the walls of the casting to be uneven in thickness.

The casting can be released from the mold:

1. By making the mold divided lengthwise clamped together so that it can be opened quickly. But it is not always possible to prevent fins forming in the joints. It can therefore not be used in cases where those fins are objectionable in further working.

2. By having the bottom and the cover loose and fixed to the mold by bolt clamps, in such a way that they can be easily detached. The mold is then rolled into a stripper, which forces out the casting by hydraulic.

3. By the driving shaft entering the bottom of the mold and being attached to a movable inside bottom. While the mold is held down the shaft with the bottom is pressed upwards by hydraulic and forces the casting out of the mold. This operation in itself is the easiest and most rapid but the apparatus becomes complicated, more time is consumed between the castings than by removing the mold, but above all it is objectionable to cast on an inside false bottom. If this is made tight from the beginning it will swell by the heat so as to make it stick. If it is made loose some metal will run out in the joint.

4. Casting.

When the liquid strikes the bottom of the mold rotating at full speed it is instantly thrown up against the sides. In a mold of cast iron cold splashes will then form as indicated on Fig. 6. The seams between those splashes will be deeper in proportion to the difference in temperature between the metal and the mold. Low carbon steel and cold cast iron molds present in this matter an extreme case. Cold splashes occur however quite frequently in ordinary stationary molds cast from the top through the bottom of a ladle containing the whole charge. This especially happens in the first cast ingots when the speed of the jet is accelerated by the whole overlaid height of metal in the ladle. But the splashes are worked away in further operations. This may therefore be done in some cases of centrifuged castings but in others it cannot be done. By heating the mold the clefts between the splashes become less deep and the metal is kept liquid longer. But if the heat shall do any good it will have to be raised so high as to come dangerously near the temperature where the melted metal attacks the cast iron mold. The same object will be obtained by having the mold clay lined, but the surface of the casting will get rough and require more working to be acceptable.

By experimenting with melted paraffine in brass mold I have found that cold splashes are avoided by arranging the inserted spout so that the liquid is discharged horizontally impinging on the sides of the mold where the centrifugal force places it. The appearance is somewhat like Fig. 7 with helical marks very faint and shallow.

By pouring the liquid in a stationary mold and then rotating, I found that the casting presents an appearance somewhat like Fig. 8. The part below the line of rest has the appearance of an ordinary cast ingot with surface blow holes, if the steel is not dead molten and cast at a low temperature. But the upper part presents a perfect outside surface. The demarcation line between remains however quite deep and distinct.

If the mold is made to rotate slowly during the casting and then brought up to full speed there will be no such demarcation line. The lower part has a surface no worse than ordinary cast ingot but the upper is so near faultless as can be. In both of the last named cases a solid bottom closes up the casting which however can be either cut off or pierced in further working. This solid bottom gives the advantage in stripping that the pressure can be exerted only by a rod forced in the center hole fitting over the upper end of the driving shaft and the bottom of the mold needs not to be detached.

The inside of the casting follows faithfully the paraboloid cut off in the mold. As shown above even at a moderate speed the parabola straightens out to prac-

tically a trunkated cone approaching a cylinder. Tube makers do not object to a slight difference in the diameter in both ends, but a cross section anywhere must show the same thickness all around because any unevenness in that respect can not be corrected by any subsequent working. In a vertical smooth running mold the centrifugal force takes care of this matter as it is not one sidedly affected by the gravity. Although the inside is perfect in shape the pretention that it shall be so smooth as the outside is of course unreasonable. With exception of cast iron hollows it will have to be worked into shape. For the case of tube billets to be rolled over mandril it is therefore advisable that the inside be first reamed out which could easily be done in the same operation as forcing out the casting from the mold.

In all centrifugal castings a measured quantity of liquid metal has to be poured into the mold, which means pouring over lip from hand-ladles. The melted charge has then to be kept hot while waiting. To accelerate the pouring and make it so continuous as possible it is preferable to have 3 machines to be used alternately.

The technically most suitable process is of course crucible melting. But this is now being relegated to the rear on account of the high expense of fuel and crucibles especially in producing the high temperature for melting low carbon steel. A small electrical melting furnace will of course answer the purpose if the steel can be kept in the furnace long enough without changing composition in contact with the basic bottom and phosphoretic slag (there have been cases where the carbon in the steel reduces back some phosphorous out of the slag by long contact after refining).

A 2-ton side blow converter seems to fill the requirements. The casting from such a converter through hand ladles is done just in the same way as it would be in serving centrifugal machines. The steel is kept hot in the converter on an acid bottom, covered by a blanket of acid slag and exposed to the radiation inside the converter. The slag is held back by closing the mouth of the turned down converter with bricks and the clear steel is tapped from the lowest point. By the operating mechanism the turned down converter is raised and lowered so as to measure off exact quantities in the hand ladles. The steel is hotter than in any open-hearth furnace or bottom blown converter as the carbonic oxide is burnt in side the converter, and the heat is only second to that in an electrical furnace. A 2-ton charge of pig iron melted in a cupola is converted into steel in about 20 minutes without any consumption of fuel, which is shorter operation than refining in basic electrical furnace. The side blow converter is cheaper to install and operate than an electrical furnace, the only outfit being a 60 horsepower positive blower for pressure of 3 to 4 lbs. per sq. in. and a 5 horsepower tilting apparatus.

But on the debit side stands the higher price of the low phos. pig iron to be used in the converter and the exclusion of scrap. Common steel scrap is cheaper than pig iron and the charge in a basic electrical furnace of such scrap and phosphoretic pig iron is lower in price than the charge in a converter.

Operating with small units in any furnace is of course always more expensive than for inst. melting 100 ton charges in a basic open hearth furnace. But it would be impossible to use this for measuring off small quantities, as the whole charge has to be emptied

in one ladle. Even if the steel could there be kept hot for the required long time it would be impossible to pour through the bottom into hand ladles as the pressure would make the steel flow over and spill.

5. Products.

Although, as shown above the centrifugal parabola rapidly elongates with the speed, there is of course a limit of length for vertical casting. But the majority of hollow articles fall within that limit. A cast tube with the inside tapering off to an edge, can be divided up, the upper part being used direct for drawing, the lower part used as hollow billets to be rolled over mandril.

The ordinary way of making hollow tube billets is to cast 12 in. ingots, reheat these in gas fired soaking pits, reduce the size in a blooming mill to 6 in., cut up the blooms into lengths suitable for heating and rolling into round billets, saw off these to lengths, heat and roll between disks in such a way the billet is forced against a stationary spear. On the face of it hollow billets can be worked out cheaper by centrifugal casting.

Among the many articles of limited length to be cast vertically by centrifugal force I call special attention to the following two:

The sleeves to be shrunk over the explosion chamber of a field or siege gun can be made quite satisfactory in that way and much cheaper than by the present elaborate process.

Projectiles can be made centrifugally, about as good as forged and the cavity closely conforms to the required construction, Fig. 9. All projectiles whether cast or forged have to be machined to exact finish—I found by experiments with paraffine that a small stationary pool will remain at the point of the cavity which afterwards forms a short pipe. But even this is easily corrected in further working. The great advantage is the forming of the cavity thereby saving the tremendous labor of carving out the hollows cold from forged solid blanks by using a great number of machines.

It would be interesting to fill a rotating mold so completely that no cavity can be formed and to ascertain the effect of the centrifugal force by the micro-structure.

In all the above said I have mentioned the most difficult metal which is low carbon steel to be thus treated. The work with other metals is comparatively easier.

IRON MINING PROBLEMS IN BIRMINGHAM DISTRICT

An investigation in progress at the Southern experiment station of the Bureau of Mines, Birmingham-Tuscaloosa, Ala., relates to the location of low-grade high silica iron ores, the support of mines and the ventilation of the mines of that district. Large blocks of iron ore will be cut to uniform size and tested with a view to determining their crushing strength as a basis for the calculation of size and arrangement of pillars in the mines. Subsidence in iron mines will also be investigated, involving a careful study of surface and underground conditions. Metal-mine ventilation and the dust problem are to be studied in a manner similar to that which has been followed by the Bureau of Mines in certain metal-mining districts of the North and West.

Fuel Economy in Heating Furnaces

New Methods to Obtain Increased Production With Decreased Fuel Consumption from Regenerative and Recuperative Furnaces.

By K. HUESSENER

Mgr. American Heat Economy Bureau, Pittsburgh, Pa.

NOTWITHSTANDING the fact that regenerative and recuperative furnaces have been in use for close to half a century, there are no generally recognized rules governing their design. Most builders of furnaces have their own set ideas, mostly based on empirics. This is, not by any means, confined to any particular country, but holds true all over the world. One eminent German authority is quoted to say quite recently that metallurgical furnaces differ from stables more in material used than in any other way, thus reducing the matter ad absurdum. May that as it be, there is no denying the fact that a large majority of furnaces are of haphazard design, rendering it extremely difficult for the operator to obtain satisfactory results.

In examining heating furnaces from a strictly theoretical point of view, we find that output and economy go

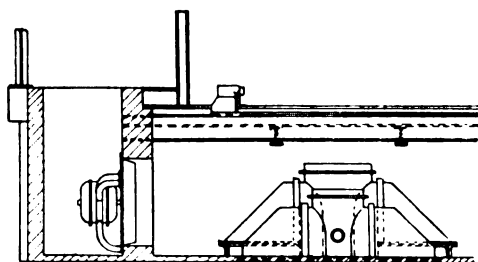


Fig. 1.

closely hand in hand—as the following simple calculation will show, using the following characters:

W = sensible and latent heat of gas and air admitted at the port

W' = heat remaining in the furnace

N = heat transmitted to the material (process heat)

S = heat transmitted to the walls (radiation and conduction losses)

$$W' = (N + S)$$

$(W - W') = E$ = heat going into the outgoing regenerators

N' = heat transmitted to gas and air by regeneration

S' = wall losses of the regenerators

E' = heat going to the stack

$$E = (N' + S' + E')$$

G = weight of waste gas resulting from combustion of W

c = specific heat of waste gases, assumed to be the same for all parts of the furnace

t_a = calculated initial temperature

t_e = temperature of waste gases entering the regenerators

We obtain the following equation illustrating the course of the heat through the furnace:

$$W - (N + S) = N' + S' + E'$$

The heat contained in W is equal to the weight of the waste gases multiplied by the specific heat and the calculated temperature

$$W = G c t_a$$

which is reduced when entering the outgoing regenerator to:

$$E = N' + S' + E' = G c t_e$$

therefore the heat remaining in the furnace

$$W' = (N + S) = G c t_a - G c t_e$$

and as the efficiency of the hearth is expressed by the relation of the heat admitted to the heat retained:

$$\frac{G c t_a - G c t_e}{G c t_a} = \frac{t_a - t_e}{t_a}$$

The efficiency of the furnace is therefore in direct relation to t_a and in reversed relation to t_e . Very little influence can be exercised on t_e which is bound to be above the temperature of the treated material. The attention of the operator must therefore be given to obtaining as high an initial temperature as is consistent with the material used in building the furnace, and with the process temperature required.

We have, however, seen that only part of the heat remaining in the furnace is transmitted to the bath or the heated material, and that another part, unfortunately the greater, is transmitted to the walls and lost through wall losses. These wall losses are not in any way dependent on the quantity of heat W admitted, but are governed by the difference of temperatures of the inside and outside of the furnace walls. They are, therefore, for any given type of furnace and temperature t_a , fixed losses and their percentage proportion to the heat W admitted will be in a reversed relation to the quantity of this heat.

We have seen that:

$$N + S = G c t_a - G c t_e$$

or

$$N = G c (t_a - t_e) - S$$

In other words, once the highest admissible temperature t_a has been attained, t_e and S being fixed quantities, N the heat transmitted to the material is dependent on the $G c$, which in turn is dependent on the quantity of latent and sensible heat admitted in gas and air.

In following the course of the waste gases through the outgoing regenerators we find that

$$G c t e = N' + S' + E'$$

or

$$N = G c t a - (N' + S' + E') - S$$

As $G c t a$ is made up of Wl , the latent heat in the gas, and Ws , the sensible heat in gas and air, and $Ws = N'$, or

$$N = (Wl + Ws) - Ws + S' + E' - S = Wl - (S' + E') - S$$

we find that the efficiency of the furnace will increase with the increase of the latent heat and the decrease of the stack losses E' . The wall losses of the regenerators S' being fixed quantities same as the wall losses of the hearth S for the above stated reasons.

In order to reduce the chimney losses as much as possible it will therefore be necessary to store as much heat N' as possible in the outgoing regenerators and take it up again as Ws in the incoming regenerator. The heat transfer in the regenerators is almost exclusively by contact and is therefore in direct relation to the velocity of the gases passed through them, and to the squares of the absolute temperatures. If larger quantities of gas and air are passed through the regenerators this will certainly result in larger velocities. We have seen that to must be considered a fixed temperature, so that when working with larger quantities of waste gases the heat transfer will only be benefited by the velocities in the first outgoing period. On the next incoming period the larger quantities of gas and air, if both cold, or at least of the air only, if hot producer gas is used, will result in cooling the regenerators to a lower temperature and thus also assist the heat transfer, with the result that E' is correspondingly reduced. How far a reduction of the chimney gas temperature when working with larger quantities of gas is actually possible, will depend on the size and design of the regenerator, but experience has shown that the chimney temperatures are as a rule not increased where the load put on the furnace is increased, so that the final efficiency is as a rule not unfavorably affected by the chimney losses.

The calculation proves that to obtain better efficiencies from any given furnace it is necessary to increase the initial temperature and to pass as large as possible a quantity of heat through it.

To refer to the latter requirement first, it must be kept in mind that the amount of gas which can properly be burned in any given furnace depends on the sizes of the regenerators and of the stack, the former to provide as large as possible a quantity of gas and combustion air, the latter to convey a correspondingly large quantity of waste gas to the waste heat boilers or into the atmosphere. On account of the fact that the gas regenerators are usually of the same size as the air regenerators and that the gas is supplied to them under pressure, there is in the majority of cases no difficulty to supply very much larger quantities of gas to the furnace. Not so with the air. The air enters the air valves under atmospheric pressure and its quantity is dependent on the chimney effect of the regenerator.

In examining the possibilities of a furnace, one will first of all ascertain whether the air valves are wide open during operation, and to what extent the possibilities of the stack are utilized. In case one finds that one operates with wide open air valves and partially closed chim-

ney damper, the conclusion is justified that the furnace can deal with more gas, provided that the air supply is correspondingly increased. The possibilities of the stack are only exhausted when with a wide open damper balanced draft is maintained in the hearth. A large enough chimney is, therefore, always a chief requirement for the proper utilization of a furnace. In case the chimney should be too small it will almost always pay to equip it with an exhaust fan.

To provide more air was hitherto not simple. Larger regenerators which offer the obvious remedy are in the majority of cases out of the question on account of lack of space, quite apart from the expense. To supply the

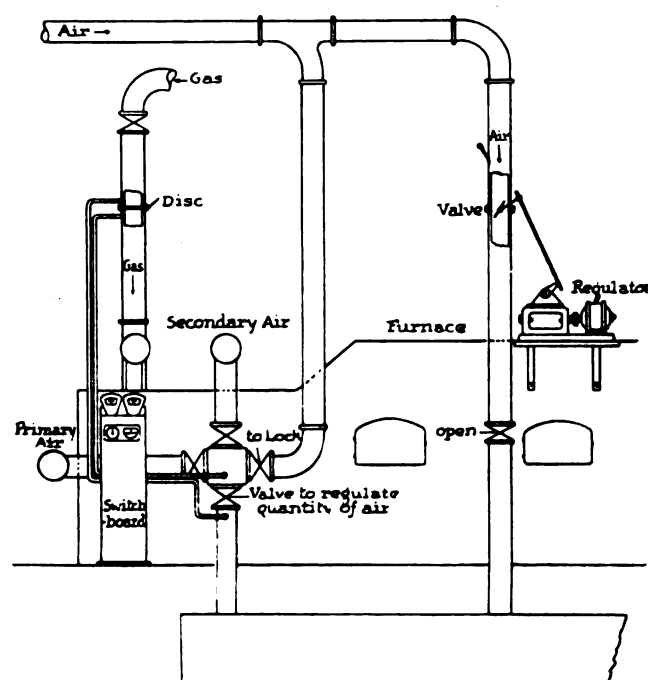


Fig. 2.

regenerators with air under pressure by connecting the air valve to an air duct and blow air into this duct by a fan forbids itself in the majority of cases for various reasons.

The great majority of air valves are situated either in valve pits, or in cellars, and are usually so cramped in that it is impossible to accommodate the air duct and the fan. It might be possible to provide a long air pipe and locate the fan outside the pit or cellar. The result, however, would be total loss of ventilation and such an increase in heat in the pits that it would be impossible for the men to work in them and to give valves, levers, etc., the required attention. The increased heat in the pits would naturally also result in greatly increasing the temperature of the floors on which the men are attending to the furnace.

Another very vital objection to this kind of air supply is the fact that the furnace becomes dependent on the working of the fan, and in case of breakdowns of the fan motor or the central power plant, the furnace would be closed down.

A method of supply of air which overcomes all these objections, and which for some years has been used with very great success on a number of heating furnaces, has been developed and patented by Mr. Alfred Steinbart. Instead of using the ordinary centrifugal fan and the air duct, he arranges the pit in such a manner that it is as

nearly as possible air-tight and equips it with a propeller fan built into one of the walls of the pit. (See illustration.) Where the valves are situated in cellars he builds a small casing around the valve and equips this casing in the same manner with an ordinary propeller fan.

The regenerator usually creates a draft of about 2/10 in. w.g. which determines and limits the quantity of air to be handled by it without outside assistance. In order to increase this quantity a certain additional outside pressure has to be set up. Assuming that the chimney effect of the regenerator of 2/10 in. w.g. can handle 5,000 cu. ft. of gas per minute, and it is desired to increase this quantity by 25 per cent to 6,250 cu. ft. per minute, the pressure to be set up by the fan (x) is found

$$\sqrt{.2}$$

from the following equation:

$$\sqrt{.2 + x} = \frac{5000}{6250} = \frac{5}{6.25}$$

(The quantities of air passing through a given area are in proportion to the square roots of the static pressures in inches of water.)

A propeller fan to set up this additional pressure of 1/10 in. w.g. requires a little over 1 hph. The 25 per cent additional air will as a rule be sufficient to increase the output of the furnace by 30 and more per cent.

An installation of this kind has manifold advantages. Besides being inexpensive, the installation can be made without stopping the furnace. If the fan for any reason whatsoever should break down, the furnace will not be stopped as the old conditions of air supply can immediately be restored. In addition to supplying the furnace with additional air, it also supplies welcome ventilation and cools the floors on which the men are working. By choosing the fan a little larger than its actual requirements, this ventilating and cooling effect can be made very pronounced, so that the men can work in the pits without experiencing any inconvenience.

The following table gives an idea of the results obtained from an installation of this kind. A furnace having a hearth surface of 7 ft. 9 in. by 6 ft. 5 in. between bridge walls, and heating to a welding heat plates 6 in. wide, 29 in. long and 5/8 in. thick, weighing 30 pounds each, was changed over to the Steinbart method of air supply. The following are the number of plates heated before and after the installation during each shift:

Before	After
718	886
712	497
863	616
926	790
625	682
741	820
588	787
550	888
636	1244
800	1460
878	1520
1074	1508
904	1107
480	1120
10,495	13,934

The average run per shift before the installation was 750 plates and after the installation 995 plates, an increase of 32 per cent.

When, a short time later, the fan was stopped, one Saturday morning, the results were as follows:

9:00-10:00 A. M.	126
10:00-11:00 A. M.	130
11:00-11:45 A. M.	97

On the following Monday the fan was put back to work with the following results:

9:00-10:00 A. M.	155
10:00-10:55 A. M.	154
11:00-11:50 A. M.	148
2:00- 3:00 P. M.	166
3:00- 4:00 P. M.	166
4:00- 4:55 P. M.	154

an average per hour of 168½ with the fan as against 128 without the fan, an improvement of 31½ per cent.

The main saving from an installation of this kind is of course in wages, as the same set of men will produce 30 per cent more product than before. The fuel saving, although it must have been considerable as shown by the above calculation, could not be determined, as a number of other furnaces were receiving gas from the same gas house. It can only be correctly ascertained when all the furnaces served from the same gas house are equipped in this manner.

Whilst the above described method takes care of working the furnace with the possibly largest consumption of gas and a correspondingly increased load, it does comparatively little towards increasing the initial temperature t_a , which we have found is the other determining factor in increasing the efficiency and reducing the fuel consumption of the furnace. This temperature depends on two factors:

1. The always correct proportion of gas and and combustion air.
2. A thorough and intimate mixture between the two.

The second factor is dependent on the construction of the furnace and can in the majority of cases not be influenced without very considerably changing the furnace ports. But a certain maximum temperature can be obtained in any furnace and frequently in excess of the temperatures actually obtained, or where higher temperatures are not desired, the same temperatures can be maintained with a much smaller expenditure of gas, if the gas and air are supplied in a predetermined relation and if this relation is continuously and automatically maintained.

The required initial temperature for the various kinds of metallurgical furnaces are very different and vary from 1900-2000 deg. F. for hardening furnaces to 4500-4700 deg. F. for open hearth furnaces. These are calculated initial temperatures, as they would be obtained if gas and air were burned in the possibly smallest space without transmitting any heat in statu nascendi by radiation to the surrounding walls, etc. The actual obtainable temperatures are much lower and depend on the pyrometric efficiency of combustion, amounting usually to 68-75 per cent of the calculated.

We are dealing in this case with regenerative and recuperative furnaces only, where the required actual temperatures vary from 2400 to 3200 deg. F. The heating value of the gas and the sensible heat carried by gas and air after pre-heating are factors which we must consider as fixed for any given type of furnace. Whatever they are, gas and air should always be mixed in a rela-

tion as near as possible to the theoretical for perfect combustion, and automatically kept there. If the obtained flame temperature is too high a reduction in the gas supply will decrease the pyrometric efficiency and cool the flame. As in metallurgical furnaces, the danger of considerable material losses through scaling has to be countenanced, a reducing flame is generally called for, and to be on the safe side it is customary to work with a considerable excess of gas, a very wasteful proceeding and apt to entirely defeat the primary object of obtaining the highest practical initial temperature, compatible with the temperatures required in the furnace.

There is naturally no possibility to lay down hard and fast rules for all furnaces as to the best proportion between gas and air. There are a good many other factors which have to be considered, such as the minimum volume of products of combustion required, the temperatures which have to be maintained in certain parts of the furnace, which may call for slow combustion with a lingering flame and many other individual conditions, but there cannot be any doubt that there is one and only one best condition where the desired relation of gas and air gives the best all-round results, and that any deviation from this condition will always be to the worse. It is this condition which should always be maintained automatically, no matter how much the gas supply to the furnace changes.

Attempts have been made of late to educate the furnace men to regulate the air supply by hand. Such regulation is, however, not practicable and at best very crude. At most mills it is still customary to work with an entirely open air valve and let the relation between gas and air take care of itself, increasing the gas supply whenever one is in danger of obtaining a highly oxidizing flame.

The Askania gas and air mixing regulator has been designed to automatically maintain this desired relation between gas and combustion air. The illustration No. 2 shows the application of the regulator to a recuperative furnace which receives its combustion air through a special air duct by fan pressure. It will be noticed that an orifice is arranged in the gas supply pipe and that the dynamic pressure, i. e., the difference of pressure before and behind the orifice, is taken off in the customary manner. The air valve in this case is of the slide valve type. The slide forms the air orifice, the differential pressure being taken off in a similar manner.

These two dynamic pressures change in proportion to the quantities of gas and air passing through the orifices. In order to keep the quantities of gas and air in constant relation, it is necessary to keep a constant difference between these two dynamic pressures. This is done in the following manner: The two pairs of differential pressures are first passed through a pressure transformer and reduced to two working pressures. Suppose for instance that the two pressures taken from the gas orifice are 50 and 30 mm, and those taken from the air orifice 30 and 15 mm, then the two transformer pressures are $(50 - 30)$ 20 and $(30 - 15)$ 15 mm. The difference between these two is therefore 5 mm.

For the purpose of obtaining this result the two transformed pressures of 20 and 15 mm are admitted on either side of a diaphragm which divides a contact box into two compartments. This diaphragm is set by a simple screw set for 5 mm in the above assumed case. Assume that a change in the quantity of gas results in a change of the transformed dynamic gas pressure from

20 to 25 mm. The difference, which should be held at 5 mm, is now changed to 10 mm and the diaphragm will make an electric contact. Through a suitable gas relays a motor is actuated which in turn opens a butterfly valve in the air main and admits a correspondingly larger quantity of air until the transformed dynamic air pressure is increased to 20 mm, thus restoring the desired difference of 5 mm. As soon as this is done the contact is broken and the motor is reversed, which is necessary, as naturally the regulation limits will always be a little over-run. In this manner the motor will all the time run 20-30 revolutions in one direction, then reverse and make another 20-30 revolutions in the other direction, major changes being taken care of by a correspondingly increased number of revolutions in the required direction.

A regulator of this kind is also necessary where the gas supply to the furnace is kept constant by special pressure regulation valves, etc. In a regenerative furnace where the chimney effect of the regenerator supplies the air, this amount of air gets smaller and smaller towards the end of the heating period in the same proportion as the regenerator gets cooler. A reduction in the air supply upsets the desired pressure difference of 5 mm in a like manner as if the gas supply had been increased, and will be taken care of by the regulator in exactly the same manner.

The installation shown in illustration No. 2 is the application to a producer gas fired heating furnace. The furnace before the installation was using 42,000 cu. ft. of producer gas per hour. Already four hours after the installation had been started, the gas consumption was reduced to 28,000 cu. ft. per hour, and later on an additional reduction of the gas became necessary, as the flame temperature rose to such an extent that it threatened to destroy the furnace ports and arches.

NEW ANNEALING FURNACE FOR WIRE

New annealing equipment for wire, including a furnace and a carriage for annealing pots has been developed by Michael B. Kelly, president and general manager of the American Steel Co., Pittsburgh, and Hugh J. Scanlon.

The inventors state that the object of their invention is to provide a unit in which the temperature at different parts of the chamber may be properly controlled, causing an efficient application of heat to all parts of the annealing pot. The furnace also is designed to permit a gradual increase in temperature as the material moves from the entrance end of the furnace to a certain point and then a gradual decrease until the material arrives at the discharge end.

The furnace proper and the chamber rest upon a concrete foundation. The floor of the annealing compartment which carries the annealing pot carriages is inclined from the entrance to the discharge end to facilitate the movement of pots. The roof slopes down in either direction from the point where the heating furnace adjoins the annealing chamber. Definite specifications for the furnace proper are not given, it being stated that any suitable design embodying a stoking apparatus and equipped with a motor-driven blower may be used. Heat is supplied to the annealing chamber through connecting ports from the furnace and the products of combustion pass out through a stack situated along side of the charging end.

Breakage of Rolls on Sheet and Tin Mills

A General Discussion on the Warming Up of Rolls for This Type of Mills—Author Explains Why Some Methods in Use Today Are Disastrous.

By W. H. MELANEY

PART II.

CONTINUING the discussion of the probable reasons for the breakage of sheet and tin mill rolls as outlined in the preceding article, the writer will endeavor to present in a logical manner some of the methods in use today for warming up these rolls preparatory to the rolling of sheets, and primarily intended to prevent, so far as possible, their breakage under service conditions.

As previously shown, thin sheets such as are produced on a sheet or tin mill must of necessity be rolled on hot rolls, as due to the thinness of these sheets even when rolled in packs, it would be impossible to keep them up to a temperature that would permit of the proper elongation of the packs, if any external means were used to keep the rolls cool. Besides, the rolls themselves would so rapidly absorb the heat from the pack that nothing short of drenching them with water would prevent their rapid heating anyway.

This would be prohibitive, because whatever means were used to cool the rolls would also cool the sheets.

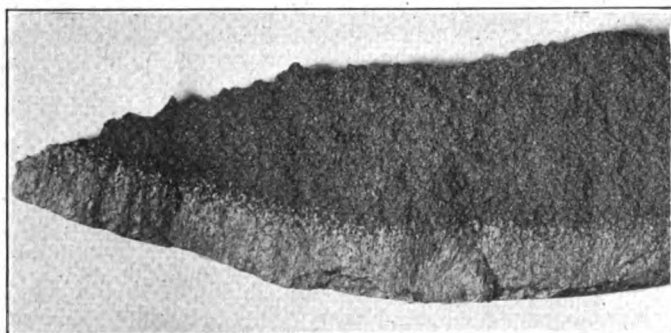


Fig. 1—Chill Roll Structure.

Therefore, we must accept the hot rolls as a necessary evil and see what means we can employ to render this condition least dangerous, at least so far as roll breakage is concerned. The mere fact that rolls are hot (if they are kept within practical limits) does not materially increase the danger of breakage, as they can easily be kept within the critical temperatures of the maximum and minimum strength of cast iron and still do good work.

Imparting Heat to the Rolls.

Most of the trouble arises in imparting to the rolls the initial heat required to eliminate the concavity previously turned in them, as the simplest and most practical means of taking care of the puffing up of the center of the roll face which is a natural sequence to the rolling of the red hot packs, the center of the rolling face becoming very much hotter than it is at the ends of the roll.

This is self evident, as in rolling wide sheets (and these are always rolled in the fore part of the week, just as soon as the rolls can be brought up sufficiently full in the center to permit it) the red hot packs are uniformly in contact with the rolling surface over practically its entire face.

The center of the roll has no means of losing any of its heat except by radiation into the surrounding air, while the ends of the roll not only lose heat by radiation, but also by conduction into the necks and wabblers.

The amount of tonnage, that is, the number of packs that are to be put through the rolls in a given time, will determine the amount of concavity that must be turned into the rolls at the start. The greater the number of packs rolled in an hour the less the chance of the roll losing heat from its center by radiation, therefore, the more the concavity must be at the start.

With this explanation of the conditions that always exist on these types of mills, we will take up the manner of imparting to the rolls the initial heat required to bring them into workable condition.

From the description in the previous articles of the vastly different physical characteristics that must exist between the metal on the face of the roll and that of its interior, it follows as a logical conclusion that this initial heat should be permitted to slowly accumulate in order to give the interior of the roll time to warm up sufficiently to take care of the quite rapid expansion of the crystalline face by the greater mass of the granular interior, even though the expansion of the granular mass, inch for inch, is only half as great as the crystalline face. (See illustration of chill roll structure.)

Old Method of Warming Up.

The old time method of warming up the rolls in use for many years, and which, fortunately for everybody concerned, is fast becoming antiquated and generally obsolete, was to warm up the rolls by rolling a certain number of short pieces of sheet bar in the center of the rolls to bring up the center a little until narrow sheets can be produced which will come within the commercial limits of even gauge. As the rolls accumulate heat, the width of the packs is increased until the wider sizes of sheets can be rolled.

By this method of warming up it is apparent that the chilled face of the rolls (starting at the temperature of the surrounding air in which they have reposed for at least a week after being turned) must be very rapidly heated as they come into direct contact with the hot steel.

As a sheet bar is usually only 8 in. wide and as the bar is entered sidewise into the rolls, there will only be a contact of 8 in. in width for a distance across the face of the roll corresponding to the length of the bar being

rolled. Of course, due to elongation, this width of contact is increased after each pass, but at best the rolls are only heated in spots from direct contact with the hot steel. Thus, it requires many passes and many revolutions of the rolls before all parts of their rolling face have been in contact with the hot steel.

When, as oftentimes happens, the rougher and catcher get so proficient in entering the bars as to have a stated number of seconds between each pass, then this rhythmical action results in the bar entering at practically the same point on the circumference of the rolls at each pass. This results in a very uneven heating of the roll around its circumference, producing the worst possible condition as regards expansion that could occur, with the chances good for starting a rupture in the face of the rolls that will cause them to break later on.

This is one of the reasons for the statement many times, by the roller, that the roll broke without apparent cause, as the roll had not been abused or in any way misused previous to breaking.

Warming Up With Gas.

The next step in advance was using natural gas in the beginning of the warming up process to at least raise the temperature of the roll above the extremely low point it had acquired in lying idle for a week, especially in the winter time, then following this up with short pieces of red hot bar, as previously explained.

This innovation would have a beneficial effect if the rolls were kept constantly revolving and the gas flame evenly applied all across the face of the roll instead of as was often the case of a single gas flame being projected against the middle of the rolls, causing an uneven expansion of the two rolls.

This method, while having some good features when properly applied, was usually resorted to before the mill crew arrived to take charge of the mill, and being in the hands of men unacquainted with the sensitiveness of chilled rolls to heat conditions, was generally badly abused and probably did more harm than good.

As an illustration of the thoughtlessness with which these things are some times carried out, the writer remembers an instance in which a blow torch was used to quickly heat up a pair of rollers preparatory to placing them in service.

Another illustration was the placing of a cold chilled roll in the winter time on a hot annealing box bottom to partly warm it, with the result that the roll fell in two before ever going to the mill. This was due, of course, to the too rapid and uneven heating of the roll.

Steam Heating.

Later on steam was introduced as the warming up medium, as by this means the rolls could be gradually heated to approximately 150 deg. F., and this heat would extend clear through to the center of the roll and thereby relieve the extreme difference in temperature between the surface of the roll and its interior, before the final warming up with hot bars was attempted.

This was a big step in advance of any previous method, as at no time was there any very rapid heating until the roll had at least become warm all through and the rapid heating of the face of the roll over a cold interior was avoided.

Hot Water Heating.

Then came the most advanced and best system of warming up in use on sheet or tin mills to date, that of hot water heating.

A cold water line is always in service at the sheet

or tin stand anyway, as it is necessary to furnish the water used in controlling the temperature of the necks.

Now, if a perforated pipe be suspended across the top of the rolls the same as is used on a balanced roughing mill, and connected to the cold water supply, and then a steam line be connected into the cold water line right at the mill stand, so that by opening a valve the steam is permitted to circulate through the water, then the water can be heated to the boiling point and distributed through the perforated pipe over the whole surface of the roll, the motor being rotated to turn the rolls over the whole time the warming up is taking place and which requires from five to six hours.

By this method the rolls are very slowly and evenly heated from end to end to near the boiling point of water, and this heat extends clear through to the center of the roll, thus putting them in excellent shape to receive the final warming up by rolling crop ends or narrow sheets until the mill is ready to roll the width of sheet desired. Then by limiting the number of pairs that may be rolled by any crew over a given number of hours, changing the limit as the heating up progresses, until about the middle of the week.

By this time a condition is reached where the limit can be removed and the crews permitted to make up during the later part of the week the tonnage that these restrictions prevented in the fore part of the week.

This, as will be seen, does not reduce the output when the whole week's work is considered, but does insure a more careful warming up, the result being less broken rails and a much lower cost per ton of sheets.

Not only do broken rolls raise the cost of rolled sheets per ton to the extent of the money loss on rolls over a given period, but the consequent stoppage of that and other mills driven through it while roll changing is taking place, reduces the tonnage rolled until some times the loss is greater from this cause than that due to the breaking of the roll.

Besides, while the mills are down the heat conditions in the rolls are continually changing and it is necessary to resort to more warming up before the usual width of sheet can be rolled and which is conducive to further breakage of rolls, so it would seem to be the better part of wisdom to prolong the time of warming up the rolls during the fore part of the week, even at the cost of reduced tonnage, because this can always be made up during the later part of the week with very little danger of roll breakage after the rolls have been brought gradually up to their ideal working temperature of from 700 to 750 deg. F.

The next article will deal with the roughing up of the surfaces of sheet and tin mill rolls.

BRIER HILL NOT TO BE IN NEW STEEL MERGER

Reports that the Brier Hill Steel Co., Trumbull Steel Co., and the Steel & Tube Co. of America are to be included in the merger of independents forming the North American Steel Co., have been denied by Thomas L. Chadbourne, New York, counsel for the merging companies. The combine will include only the Republic Iron & Steel Co., Midvale Steel & Ordnance Co. and Inland Steel Co., it is asserted. According to Mr. Chadbourne, progress is being made in closing the merger, although no date has been set for asking stockholders of the respective companies to ratify the terms of the plan. No date is to be fixed until the federal trade commission has given final approval of the terms.

The Trend in Rolling Mill Drives

The Plants Have Become More Extensive and as the Power Requirements Have Increased the Distances Involved Have Outgrown Steam Transmission.

By GORDON FOX*

IN the not distant past steel mills in general had not achieved the magnitude common to many present day plants. Their power demands were moderate. The steam engine was available and was the obvious means of main roll drive. Had suitable electric motors been then developed their use would have been questionable. The engines employed for mill drives were comparable in size and economy with those available for power generation. There was then little to justify the use of the electric motor for driving the main rolls.

Today conditions are changed. The plants have become extensive. Their power requirements have increased. The distances involved have outgrown steam transmission. Large turbines and gas engines have been perfected, having economies much higher than mill drive engines. Suitable electric motors have been developed for driving the main rolls. Just as isolated power plants are being generally superseded by central stations, so is power production being concentrated in the steel mill. Electric drive has proven its case. The trend seems unmistakable. It may be of interest to review briefly a few of the considerations which have dictated this trend.

One of the principle factors leading to the general adoption of electric drive is economy of power. It is impossible to set forth general figures which are all inclusive. But they may be used to depict the story.

It might seem that the conversion of mechanical power to electric power in the generator and the later reconversion to mechanical power at the motor, involves extra steps which would prove prohibitive. Such is not the case. The various efficiencies involved are approximately as follows:

	Reversing Mill	Continuous Running Mill
Electric Generator	93	93
Transmission	95	95
Flywheel set	80	..
Train motor	90	90
Conversion efficiency	67	84
Resultant overall efficiency	63	75

The modern steam turbine of 10,000 kw capacity will have an overall economy of 15 lbs. of steam per kw hr. or better, with prevailing load conditions. This corresponds to 10.5 lbs. per brake horse power hour. A reversing drive, with an overall efficiency of 63 per cent, will then require 16.5 lbs. of steam per brake horse power at the mill pinions. A non reversing drive will require about 14 lbs. of steam per brake horse power.

It is rather difficult to establish representative figures for steam drives as data is relatively meager and

*Mr. Fox is Electrical Engineer, Freyn, Brassert & Company, Chicago, Ill.

published results are somewhat at variance. Moreover, results depend upon many factors such as type of equipment and its condition and upon the character of the rolling schedules. However, no injustice is done these engines if the following figures be used:

	Reversing		Non
	Simple	Compound Condensing	Reversing Condensing
Per I hp hr.	45	30	20
Per B hp hr.	53	36	23

A comparison of the above figures indicates that, with engine drive, the steam requirement is two to three times that of electric drive.

These figures do not tell the whole story. In the case of electric drive we have taken into consideration the transmission losses. With engine drive it is commonly found that the steam consumed at the engine must be increased thirty to fifty per cent to cover transmission and standby losses and the wastage of steam by leaks and incidental uses.

It must be considered also that a given amount of steam can be generated more efficiently in a central boiler plant under fairly uniform load conditions than in scattered boiler houses.

The comparison above is more or less indicative of conditions in the large mill where the central power plant may be of sufficient capacity to warrant the use of large and efficient prime movers. In the small plant the superiority of electric drive from a fuel economy viewpoint is less marked, provided the mill engine is of a modern and economical design. In the smaller mills, however, it will more often be found advisable to purchase electric power from an efficient central station. The small mill often grows. As it becomes larger, the benefits of electric drive usually increase. The initial electrical installation can be well suited to future growth.

Two factors which have exercised a retarding influence on the more general use of central station power are:

Lack of reliability.

Complicated and penalizing rate schedules.

The power plants of public utilities have, as a rule, achieved a high degree of continuity of power but interruptions due to transmission difficulties are still of too frequent occurrence in some instances.

Rate schedules which penalize for a long period because of the occasional peak of short duration impose a hardship which does not seem entirely warranted. Instances arise where a mill cannot be started or an order rolled because of the effect on the maximum demand. These instances lead to loss of revenue both to the steel mill and to the utility. Closer cooperation

and a fuller appreciation of mutual interests should eliminate or reduce these differences and bring about the general adoption of electric drive and purchased power in the small mill.

The more complete the electrification of a large mill, the higher is the total power economy. This results from the use of larger prime movers, from better boiler room practice and from improved load factor. The importance of a high load factor is not fully appreciated. The average steel mill load at its best is of a fluctuating nature. The load factor is commonly on the order of fifty per cent. This means relatively high fixed charges per unit output and also requires the operation of the prime movers at reduced efficiencies. The cost of power can be materially reduced if the load factor can be improved. This can be brought about by careful provision for the minimizing of peaks and by the addition of diversified load. This factor alone is an argument of no small import in favor of the electrification of steel mill yards. In a mill which is extensively electrified the power generating capacity need be only about thirty-three per cent of the connected load.

The advent of the uniflow engine has marked an advance in steam engine drive. But little data is available as to results obtained in mill practice, but it appears that the improvement in overall economy is but a few per cent and, in most cases, does not materially affect the relative status of engine vs. electric drive. Although the engine itself is considerably more efficient than its predecessors, it cannot cause a material reduction in the important items of transmission and standby losses. The steam turbine also has seen marked improvement and, due to its extensive use, there is reason to expect that it will keep pace with or outstrip its competitors.

The economy of the electrically driven mill is not greatly lowered by operation at decreased output, such as may be necessary at intervals. Reduced output has a material influence on the economy of the engine driven mill as the edling and standby losses are relatively high.

The efficiency of the electric generator and the electric motor is practically fixed by the design and this efficiency is closely maintained throughout the life of the apparatus. Through use of flow meters and electrical meters the economy of the prime movers may be subjected to constant close scrutiny. Engines are subject to more or less deterioration and their economy is likely to suffer. It is much more difficult to maintain a check upon their performance and not always feasible to maintain them in most effective condition.

Electric motor drive has proven capable of equaling or surpassing the steam driven mill in the matter of tonnage. There are comparatively few electrically driven mills whose output is restricted by the performance of the main drive motor. Electric drive has proven fully reliable. There have been a few cases where rewinding of the motor has involved several days shut-down. Aside from these instances the delays due to maintenance of electrically driven mills have proven extremely few and of short duration. The cost of maintenance of the electrical equipment is found to be about one-half or one-third of parallel steam engine costs.

The ease and accuracy with which electric power may be metered renders possible the accurate determination of power costs and the proper distribution

of expense. With engine drive a more or less arbitrary estimate of power distribution is customary.

The electric meter also assists in the study of rolling methods and pass design and has, in several instances, proven of much value in this respect.

Due largely to the ready means of measurement, data is being rapidly accumulated as to performance of electric drives and it is possible to forecast quite accurately the result to be attained.

The great majority of electric motors applied to driving main rolls have been installed at new mills. It is only of recent date that motors have superseded existing engines. It is most natural that a change from engine drive be made at a time when the engine is badly deteriorated or when the boilers require extensive repairs or when it becomes advisable to supersede the entire mill with more modern equipment. There are no doubt many cases where it will pay to supersede existing engines by motors merely for the sake of economies offered. This will depend upon local conditions, to be sure, and is governed largely by the type of existing equipment. It may be stated in general that it will prove feasible to supersede an existing simple, non condensing engine on a reversing mill by an electric motor. It may or may not be warranted to supersede a compound condensing engine. A blooming mill working to an elongation of ten will likely consume some 1,500 to 2,000 lbs. of steam per ton if driven by a simple, non condensing engine. If a compound condensing engine is used, the consumption will likely be 1,000 to 1,500 lbs. of steam per ton. The electric drive will require perhaps 300 to 400 lbs. of steam per ton of steel rolled.

It is not possible to lay down general rules as to when existing engine drives on non reversing mills should be superseded by motors. Each case deserves individual consideration. It appears, however, that the superior economy and the many incidental advantages of electric motor drive would justify the necessary expenditure in many instances.

The loss of production during the interval necessary to a change over from engine to motor drive may, in some instances, be a serious deterrent. The recent accomplishment at Steelton, Pa., in which a complete electric reversing drive for a forty inch blooming mill was installed in twenty-three days, shows what can be done when necessary.

The practice in main roll motor drives appears, in itself, to exhibit a trend. Perhaps the most marked factor is the growing popularity of the adjustable speed drive. The added convenience as well as the increased production gained through adjustable speed provision has given impetus to the adoption of this type of equipment.

There appears to be a tendency toward the more extensive use of direct current motors for main roll drives. In some cases this practice has been dictated by the requirement of very close speed regulation or by the desire for rapid speed adjustment. However, even where no special requirements exist, the direct current motor is being proposed for the smaller drives but in larger sizes than heretofore.

A new type of adjustable speed set, the frequency converter system, now has two installations to its credit. This system appears meritorious and increased popularity is probable.

The high speed motor or set, driving through reduction gearing, appears to be gaining in favor. The

principle benefits are: lower first cost of electrical equipment; higher efficiency and power factor. These benefits are particularly marked in the case of sixty cycle apparatus. The increasing use of this frequency is no doubt a factor encouraging the use of higher speed motors. The popularity of the adjustable speed drive is also a contributing factor as the first cost of many of these equipments is decidedly influenced by the speed selected.

Hydraulic drives continue in use but their field is being gradually usurped by the electric motor. The disadvantages of hydraulic drive are low efficiency, high maintenance, inconvenient control, freezing and danger from molten metal. Hydraulic mechanisms are well adapted to show linear motions. The electric motor is essentially a high speed rotary device and

must utilize screws, racks, cranks, and perhaps several gear reductions to convert to slow linear movements.

Hydraulic cylinders have a distinct field for balancing rolls and lifting tables, a field which the motor cannot displace. Hydraulic drive has a distinct advantage as applied to shears in that the torque is quite definitely restricted. A shear equipped with motor drive and flywheel is subject to breakage or perhaps a bent shaft if cold metal is cut, since protection cannot be afforded against the stored energy in the flywheel.

Hydraulic drives also continue in use to some extent due to their prior development. In some cases it may not pay to redesign a machine for motor drive due to the small demand and the development expense. In this class may be mentioned the revolving jib type ladle crane used in some Bessemer plants.

Roberts Ovens Successfully Coke Illinois Coals

The Coking of Illinois Coals With Special Reference to the Plant of the St. Louis Coke & Chemical Company

By H. V. PATTERSON, Engineer
American Coke and Chemical Company

THE steel industry has been called the backbone of the country, but inasmuch as the reduction of the original iron ore cannot be economically accomplished without the aid of coke, the coke industry may be called the spinal cord that runs through the backbone. The developments in the coking art are of paramount interest to the men who are engaged in the manufacture of iron and steel for new and better ways of making coke mean a reduction in the cost of pig iron, and this in turn is reflected in the cost of the finished steel.

The requirements for a good blast furnace fuel are so stringent that heretofore only the best coking coals of the United States have been available for the manufacture of coke that is to be used in the furnace. The plentiful supply of such coals and their close proximity to the centers producing iron are in some measure responsible for the lack of development of methods for coking the coals that are low in the constituents that are considered necessary to form a good metallurgical coke. The coke oven designers have, therefore, been satisfied to improve minor details of their ovens and the auxiliaries, but have in the main adhered to their original designs in the flues and walls and the application of heat to the coal.

The operators have been satisfied with these designs, which have generally been foreign developments adapted to American practice, because nothing better was offered. They have studied the various types of flue ovens offered and have tried to improve them, but it is generally conceded that the types now offered have about reached their zenith and that further improvements will be minor in importance. These types have all been of vast importance in the development of the coking art in this country and therefore have been of importance to the steel industry, but like all things they have had their

day and now must make way for a better type that has a broader application.

It seems to be a truism that as our natural resources begin to wane in quantity, methods of using other resources, that heretofore were considered unusable, will always be found. This is now true of the coals of this country. The good coking coals are rapidly becoming exhausted and it becomes necessary to utilize the fields that produce the feebly coking coals. The deposits of such coals are enormous and will be available for many years to come. The principle deposits of such coals that are now being worked occur in Illinois and Indiana though many states further west contain large deposits of coal that are considered to be out of the coking class.

In addition to the gradual disappearance of the coking coals, the steel industry has extended westward and the increasing freight rates have made it necessary to find a means of utilizing the coals that are close to the points at which the iron is made. It has, therefore, been apparent for some years to those with a vision of the future that a means of using the so-called non-coking coals must be developed, and the engineers concerned in the design of the Roberts oven started their work with the main idea of developing an oven that would utilize these coals and therefore make available the large resources that would otherwise be useless except as a domestic or boiler house fuel.

After a number of years' patient work and the expenditure of large sums of money, the efforts of these engineers have been crowned with success and the plant of the St. Louis Coke & Chemical Company at Granite City, Ill., is a monument to their perseverance in the face of apparently unsurmountable obstacles. The results obtained at this plant have been even better than they had hoped and it is now an assured fact that the

non-coking coal fields are open to development with an assured outlet for their product and the steel industry is no longer dependent on the rapidly disappearing deposits of coking coals in the east. In addition to the opening of the heretofore unused coal fields of the west, it is also now possible to utilize many coals from the eastern deposits that have never been considered available for the manufacture of metallurgical coke.

It is unnecessary here to go into the history of the development of coke ovens in general or the many designs of the Roberts oven that were made and discarded. It will be sufficient to describe the ovens as installed at

ovens with a capacity of 2,400 tons per day and one blast furnace producing 500 tons of pig iron per day.

The coke oven plant designed by the American Coke & Chemical Company has no radical departures from the usual equipment used in such plants, and as there are many descriptions of such plants it is unnecessary to go into detail. The coal is brought in by rail and unloaded by means of a car dumper. It is taken from the transfer car either to stock or to the hoppers from which it is delivered to the crusher. From these it is taken to the hammer mills and then to the storage bin.

The charging of the ovens is by an overhead larry

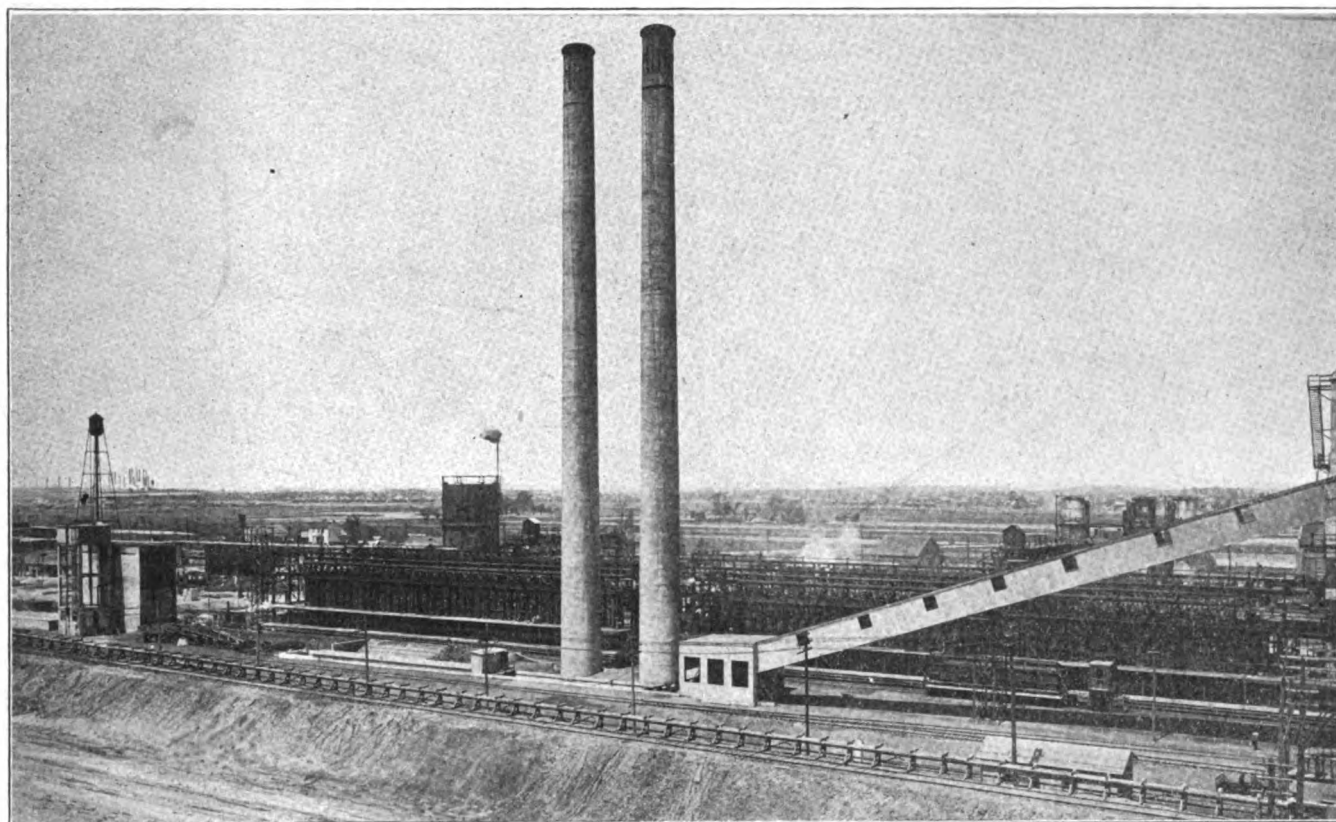


Fig. 1—General view, eighty Roberts Ovens, Granite City, Ill.

Granite City and mention the results that have been obtained at that plant when working on 100 per cent Illinois so-called non-coking coals. It may be mentioned, however, that since some of the results at this plant have become known, many others have claimed to have coked there same coals, but none of these claims has been substantiated by continuous operation. It may be safely said that the Granite City plant is the only plant in this country working continuously on the Illinois coals and producing from them a coke that not only makes an ideal metallurgical coke, but that the blast furnace at that plant, when using this coke, has made a record that has yet to be equalled by any furnace in this country. The Granite City plant is not performing stunts with one or two charges of coal, but is daily producing coke from the Illinois coals and this coke is the only fuel used in the 19,000 cu. ft. furnace which is operated in connection with the coke ovens.

The plant of the St. Louis Coke & Chemical Company is located at Granite City, Ill., and is laid out for an ultimate capacity of 3,000 tons of pig iron per day. The coke oven department is designed for 320 ovens with a capacity of 9,600 tons of coal. The first units are 80

with five hoppers; leveling and pushing is accomplished in the standard way. The gas is carried off through one ascension pipe to duplex collecting mains from which it is taken in foul gas mains to the coolers.

The by-products department is divided, the exhauster room and pump room being under one roof, but divided by walls, and the ammonia house being housed separately. After leaving the ammonia house, the gas is treated for light oils and the light oil equipment is located adjacent to the ammonia house, but not directly connected.

The rich gas is sold to nearby industrial plants and part of it is pumped about five miles to the East St. Louis Gas Company. This gas will run about 590 Btu. The lean gas is, of course, used for heating the battery. The heat value of the lean gas is about 517.

As it is the ovens that produce the coke, the readers of THE BLAST FURNACE AND STEEL PLANT will be more interested in a description of them than in further particulars regarding the auxiliaries.

The Roberts ovens as installed at this plant are of the recuperative type and are illustrated in the cuts ac-

companying this article. The gas for combustion is carried in the main battery header which occupies a position on the coke side similar to the collecting main on the pusher side. From this header the burner headers are taken through manifolds which are equipped with shut-off cocks.

The burner headers are of cast iron and are two compartment, one side carrying the primary gas and the other side carrying the secondary gas. These headers are square in cross section and the top is, therefore, flat and as the spaces between the headers is filled in, the top of the battery is smooth and readily kept clean. This is illustrated in the cut (Fig. 3).

The gas for the individual burners is taken from the sides of the headers through a shut-off cock specially

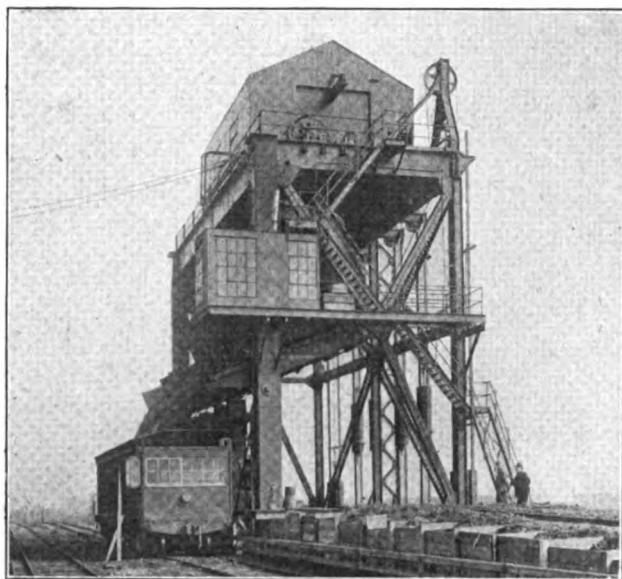


Fig. 2—View of Car Dumper.

designed for this purpose. It is by means of these cocks and the disks set in the header manifolds that the close regulation of the oven is attained.

The core of the cock is of cast iron and each core is drilled with a hole that is graduated in size from the pusher size of the oven to the coke side. The reason for this graduation is the taper of the oven. The taper or widening of the oven causes a larger charge of coal on the coke side than on the pusher side. This increase in charge is gradual as the taper is uniform. It is in all ovens necessary to burn more gas towards the coke side than is used on the pusher side if the charge is to be uniformly coked in the same length of time. Compensation for this increased charge is difficult, if not impossible, in any type of oven using but a few points for the introduction of the gas or using nozzles made of a material that does not lend itself to accurate calibration.

In the Granite City ovens, the core of the cock, being of cast iron and always being at atmospheric temperature, is readily drilled to a very accurate size and it will maintain this size under all operating conditions. There are 24 primary burners on each side of the oven and the holes for the gas are drilled with an increasing size from the pusher side to the coke side. This increase is in exact proportion to the increase in the coal charge in the portion of the oven served by that burner. This means that the proportioning of the gas is accomplished every 21 inches throughout the length of the oven. The

same exact control is used on the 24 secondary burners for each side of the oven.

The proportion of the primary and secondary gas is attained in the same way by the use of disks set in the manifolds supplying the headers. These disks are drilled with accurately calibrated holes through which the gas passes. As the quantity of gas passed by an orifice is proportional to the size of the opening and the pressure, the openings in the manifold disks and those in the cores of the cocks will always pass the desired quantity necessary for the coking of the charge in the desired time. To change the coking time it is only necessary to change the main pressures on the battery and each header and each cock will perform its duty without further attention.

The primary gas is admitted at a point about 16 inches below the top of the coal charge. At this point it meets the preheated air from the recuperators and combustion starts. The air is under control with the same accuracy as the gas, as there is a slide brick which regulates the flow of the air through the air ports. The quantity of air admitted through these ports is sufficient for the combustion of both the primary and secondary gas. The primary gas, therefore, meets 100 per cent excess air for its own combustion, for the primary gas is approximately one-half the total gas burned.

The initial combustion of the primary gas takes place in a short mixing duct where the small amount of radiant heat is extracted. As this gas meets a large excess of air, the flame temperature is subdued and as both gas and air are admitted at a neutral pressure, the combustion is carried on quietly and without the intense generation of heat that is noticed in other types of ovens.

Immediately below the mixing chamber is the typical staggered wall construction used in the Roberts oven. Here the stream of burning gas and air is divided into three parts by the wall brick, and from this point to the bottom of the wall the burning gases have a gentle wave motion that thoroughly mixes them and by impingement on the body of the wall brick the heat is efficiently and uniformly extracted.

The secondary gas is admitted about half way down the wall at a point where the primary gas will no longer produce sufficient heat to carry on the coking of the charge in the bottom of the oven. This secondary gas is admitted into an atmosphere of inerts from the primary combustion and these so dilute the oxygen present that combustion proceeds quietly and uniformly. This portion of the wall is identical with the upper portion and as the wall bricks are practically entirely surrounded by the burning gases the extraction of heat from them is continued with the same high efficiency.

After leaving the wall, the waste gases from the two sides are combined in one flue that passes under the sole of the oven. By this method, sufficient heat is produced to coke the sole of the oven in a vertical direction. This produces an ideal surface on the bottom of the charge for pushing. From the sole flue the waste gases pass into the recuperator which is composed of flues for the passages of the waste gases and around which passes the air that is to be preheated. After leaving the recuperators, the air passes up through ducts left in the separating wall that occurs between each oven.

The waste gases pass from the recuperator into an offtake that connects to the main waste gas flue and thence to the stack. The offtakes are provided with butterfly valves that control the draft to each oven. In addition to this valve there are slide dampers in each sole

flue that aid in maintaining the proper distribution of draft through the oven walls.

The air is carried to each oven through a series of six tunnels that are incorporated in the concrete pad under the battery. By using this method of air introduction, the concrete pad is maintained at approximately atmospheric temperature and can never become overheated, expanded and cracked, a condition that has harmed many batteries heretofore built.

The entire operation of the ovens is extremely simple and unless there is a radical change in coking time the daily attention of the heater is confined to observance of the main pressures and as these are under control by governors there is very little for the heater to do. If the coking time is not changed, the heater merely raises or lowers the main pressures to admit the required amount of gas for the coking time decided upon and the oven will quickly respond and continue to function with the same efficiency on the new coking time.

It is not within the province of this paper to go into the coking qualities of the different coals or discuss the properties that make a coking coal. It is sufficient to state that the designers of this oven have studied the action of the various coals and formed the opinion that the low grade coals of Illinois could be successfully coked if the heat was applied rapidly and uniformly throughout the charge in the oven. That their theories were in part correct is evidenced by the results obtained in the Granite City plant which has now been operating for over a year and a half on the coals from Illinois and from them is making a coke of such superior quality that the blast furnace is breaking all previous records for sustained operation with the minimum of coke per ton of iron produced.

The application of heat in the Roberts oven is uniform throughout the entire wall. There is but one shape in the main heating wall and this one brick forms both sides of the heating chamber. This brick is best described as a solid brick with the sides and top so cut away that when two or more are laid together there is a space for the passage of the burning gases between the ends which are left the size of the original block. This is readily understood from the drawings. The brick are so laid in the wall that the spaces in one tier are directly over the center of a brick in the tier below. This gives the gases a wave motion as they pass downward in the wall and the intimate mixture of the combustibles is assured by this wave motion and the impingement on the necks of the brick.

The ends which form the sides of the combustion space are but three inches thick and there is, therefore, but three inches of brick interposed between the burning gases and the coal charge. The center portions of the brick, however, form a series of studs that give to the wall the strength of a solid structure. The wall is, therefore, at once the thinnest and the strongest that has ever been designed.

Another factor that adds to the efficiency of the heating is the large surface exposed to the heating gases. This surface is two and one-half times the area of the surface disposing the heat to the coal charge. The result is that the transmission of heat to the coal is carried on at a very rapid rate and as all parts of the walls are uniform in construction, this distribution of heat will be uniform throughout the entire wall. The gases introduced at the primary and secondary burners are also accurately proportioned and this in connection with the continuous flow of the combustibles in one direction without reversing or cessation for any cause, forms the

most efficient and uniform heating medium ever developed for carbonizing coal. This has all aided in solving the much desired coking of the low grade coals from Illinois and other states.

The normal charge in the ovens as installed at Granite City is 15 tons, and this charge has been coked in as low as 12 hours over continuous periods. This gives a capacity per oven per day of 30 tons, the largest that is known today. The coking time of the ovens has been

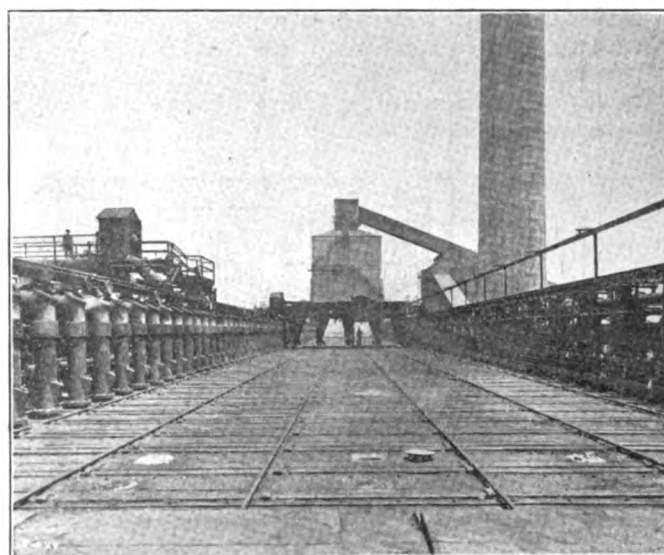


Fig. 3—View of tops of 80 Roberts Ovens, Granite City, Ill.

varied from this up to 24 or more hours with the same results—a perfect metallurgical coke. The coking time has also been changed as much as four hours within a period of 36 hours and it is not known that any other oven will show this flexibility without injury to the walls. The Roberts wall is so keyed together and is so strongly built that great variations in temperature are met without difficulty.

The average analysis of the coals used during two months of this year are as follows:

Moisture	8.06%
Volatile	34.51
Ash	9.35
Sulphur	1.38

The coke averaged—

Moisture	4.44%
Volatile	2.47
Ash	13.06
Sulphur	1.13

The yield of coke has been well over 70 per cent and the loss from breeze has averaged about 3.4 per cent. This is interesting as showing the high grade of coke produced in this oven, as it has generally been found that the high volatile coals when coked in other ovens produced a large percentage of breeze.

The tar has been about 8 gallons; ammonia, as sulphate, 25 to 28 pounds. The gas yield has averaged 10,250 cu. ft. with a heating value of 595 for the rich and 517 for the lean. The quality of the by-products from the Illinois coals is comparable to that from other coals. The yield of gas is perhaps not as high as might be expected from the volatile matter in the coal, but this is true of many of the high volatile coals that are within the reach of other systems of coking.

There is another interesting point that is well known to those who have experimented with the Illinois coals and that is the quantity of heat necessary to coke them. It is always found that the addition of Illinois coals to a mixture will at once run up the quantity of fuel gas. It is an inherent quality of this coal that it requires more heat to form it into coke than do the strongly coking coals from the eastern states. It naturally follows that those who use the Illinois coals will produce a lower quantity of surplus gas.

This was well illustrated in a plant during the war when they were compelled to use Illinois coal, as the eastern coals were not available during that period. This plant has two well known systems of ovens and as they operate as a gas company they were compelled to make

furnace coke is very high and the quality of the coke is so exceptional that furnace operators who have watched the operation of the furnace declare it to be the finest fuel they have ever seen.

The furnace is 19,000 cu. ft. capacity and was designed by Freyn, Brassert & Company of Chicago. It has been in operation for the same length of time as the ovens except for a short period last year when it was banked. The furnace has operated over extended periods (two months or more) with a production of 515 tons of pig iron per day with the consumption of only 1785 pounds of coke per ton of iron produced. A high percentage of the ores used are very refractory and yet the top temperature runs as low as 264 deg. F. The flue dust has been less than 90 pounds, and hanging and slip-

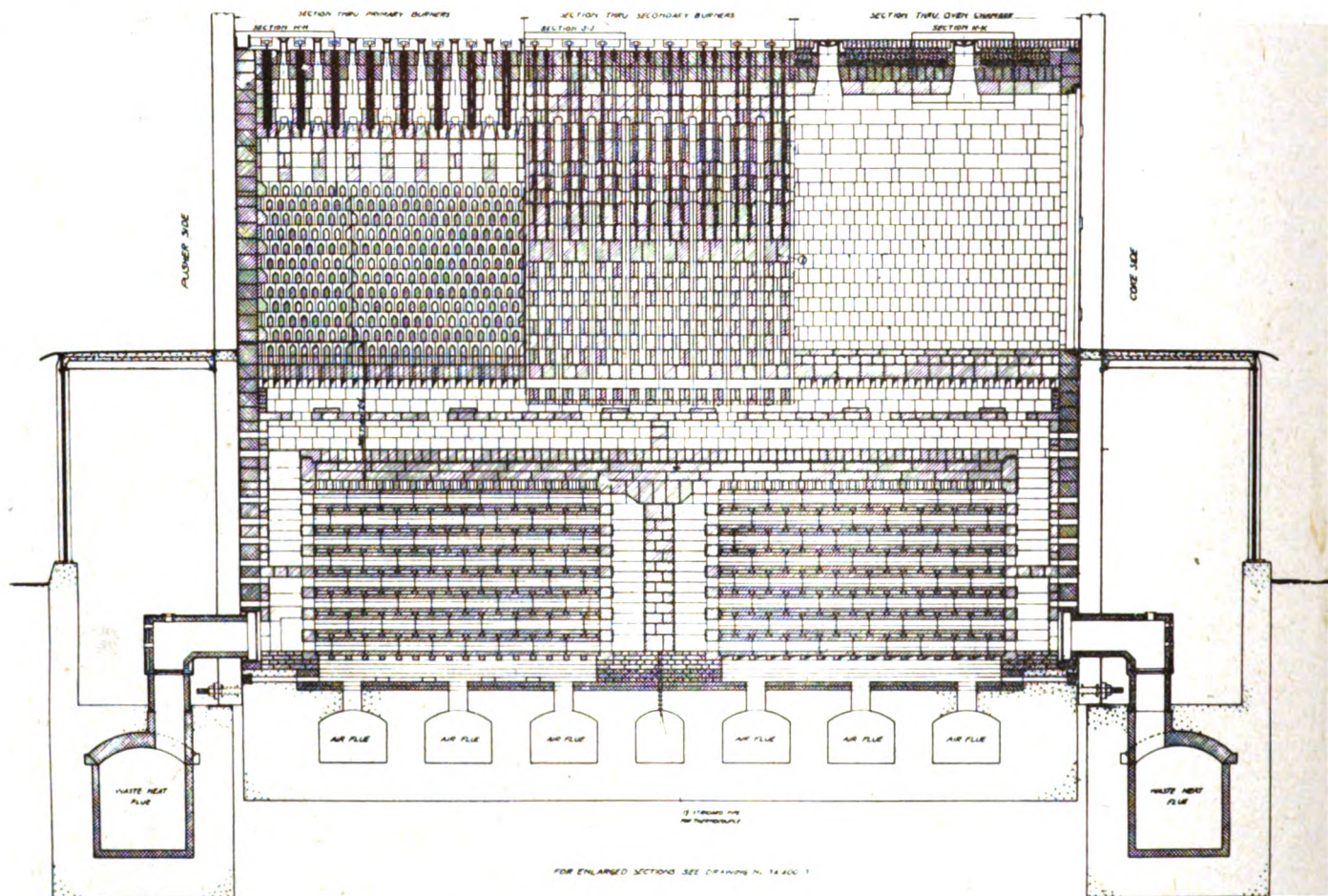


Fig. 4—Longitudinal Section through oven.

gas. They used Illinois coals and succeeded in driving off the volatile matter from the coal, but did not make any saleable coke. They at once found that the production of gas was comparable to that from the eastern coals, but that an exceptionally large percentage of this gas was required to heat the ovens. As they had been operating on the eastern coals for some years, the opportunity for comparison was admirable. They were very glad to be able to return to the eastern coals at the end of the war. However, the high heats necessary in the attempt to use the Illinois coals in those types of ovens practically destroyed them and they have since turned to water gas as a solution of their difficulties.

Part of the coke made at the Granite City plant is used in the blast furnace and part is sold for various industrial purposes and for domestic use. The yield of

ping are almost unknown, due to the fact that the zone of fusion is confined to the bosh of the furnace instead of extending upward into the shaft. It is remarkable to look in the tuyeres of the furnace and see the coke flying around amid the drops of melted iron.

The analysis of the furnace gas is about as follows and is evidence of fuel economy:

CO ₂	14.1%
CO	24.3
H ₂	3.2
CH ₄	.2
N ₂	58.0
Ratio $\frac{CO}{CO_2}$	1.72
Btu.	92

The furnace superintendent has admirably summed up the superior qualities of the coke produced by the Roberts oven from the Illinois coals as follows:

1. Absence of cross fracture, combined with uniformity of size.
2. Uniformity of cell structure.
3. Tough cell structure, permitting a heavy burden.
4. High speed of combustion—approaching that of charcoal.
5. Concentration of heat of combustion in hearth, where it can be used most economically.
6. Low transfer of hearth heat to shaft.
7. Low top temperature—longer contact of the ore with reducing gas, which means maximum stack efficiency.
8. Lean waste gas analysis, low thermal loss.
9. Low flue dust loss—more regular settling and lower gas velocity.
10. High production with low fuel consumption.

The proof of the results of the Roberts ovens is in the furnace which is operating on the coke produced in those ovens. There has been something done that was not done before, and an outlet for the Illinois coals has been provided and the steel industry has been aided, for it is now possible to use coal that is produced near some

of the large steel plants located in the west.

While this discussion has been entirely on the results produced from the Roberts ovens when operating on Illinois coals, it is well to state that they have also been operated on some of the high volatile coals from Pennsylvania. The results when using the eastern coals were what might be expected. The coking time was lowered without burning any more gas, showing that the eastern coals require less gas to form them into coke than do the Illinois coals. The coke was extremely uniform in size and the percentage of breeze and small sizes was unusually small. This is not surprising, for an oven that will produce such high results from the feebly coking coals would be expected to do much better on the well known coking coals.

The summary of this is:

That a new method of coking coals has been developed that will produce more and better coke than any of the older systems.

That the production capacity, per dollar invested, is higher than any other system.

That the operating costs of both ovens and blast furnaces may be reduced; and finally,

That a new field of coals that heretofore could not be used have now been made available to the steel industry, and furnaces will be assured of a higher grade of fuel than they have ever used.

The Manufacture of Light Steel Castings

Discussion Covering the Practical Experiences of the Author in a General Jobbing Steel Foundry Where Castings from a Few Ounces Up to Fourteen Tons in the Rough Are Made.

By H. BRADLEY*

IN this paper, which has reference to the practice of light steel castings, any reference to academic or laboratory practice has been purposely omitted. It is dealt with from the author's practical experience of a general jobbing steel foundry, making all classes of steel castings from a few ounces up to 14 tons in the rough, and with metal of carbon content varying from 0.08 to 1 per cent and over, and additionally in chrome and manganese steels.

The Plan of the Foundry.

To run a foundry successfully, the largest output with the minimum amount of handling must be attained. To carry out this successfully, the shop should be planned for the pattern to enter at one end (where there should be shelves or pockets to receive it) and the core boxes with card attached, with works order number, description, and quantity off. The card is ruled at back, so that each day's cast may be entered thereon. When the pattern and core boxes are given to the molder the card should have the man's check number marked on, together with the date.

When possible there should be a separate bay for dry sand molds. The work for dry sand should be com-

*Institution of British Foundrymen, Birmingham Conference, 1922.

menced at the end of the shop, then carried down to the drying ovens, then to the closing and casting floor, where the molds should be arranged in straight lines, and all runner bushes should be as near one height as possible, so as to avoid hoisting or lowering the ladle. The steel plant should then be fixed as near as convenient, utilizing the floor nearest to it for the green-sand molds, as these are generally of the lightest section of castings, and, therefore require the steel when in its most fluid state, to avoid short or faint-run castings.

When the steel is a little on the stiff side it can be used for the thicker section castings. The boxes, after casting, should then pass on a little further to be knocked out and examined, and a note taken of the good and defective castings and recorded on the back of the above-mentioned card. When the job is completed the card should then be handed in to the foundry office, the castings going forward to the cleaning or dressing shop, which should be at right angles to the molding shop, with tram lines running from one to the other.

The fettling or dressing shop should be equipped with shot-blast plant, oxy-acetylene burning plant, and both circular and band saws, according to size and class of work and output. The castings should then go to the machine shop and dispatch shed.

The Making of Castings.

The first thing to consider is the pattern making, which depends, firstly, on the quantities of castings required from each. A good wood pattern will withstand the making of 500 castings from it, either by hand or machine. If repetition work is carried out, then either brass or white-metal patterns are necessary, which should be on the machine for small castings. The author prefers the hydraulic machine for boxes up to 24 in. round or square, and for deep-lift patterns the roll-over machine. For anything over 24 in. the jarring machine can be used to better advantage.

The difference in making a pattern for machine molding and hand molding is that it is always necessary to fix coreprints to the pattern for the former under any parts that are undercut, as the sand is jarring downwards, therefore, it naturally falls away from the underside of any projecting part.

Tackle—The boxes should be strong, light, and made of steel. They should all be interchangeable according to the various sizes either for hand or machine. The double lug box is best, giving a truer alignment. The double lug can be either a slot and hole or two holes.

For patterns with small quantities off and intricate joint, a plaster oddside should be made, as they are easy, cheap, and durable.

For large orders or repetition work, machines are a necessity. They do good in two ways, i. e., by reducing costs, and increasing output on the jobs they are working. They also speed the work up generally in the shop. Two boys working a machine with boxes 10 in. by 10 in. by 4½ in. have produced 180 complete molds in the day with from two to four cores in each. Two youths, 17 to 18 years of age, have produced 62 molds, 18½ in. high by 16 in. by 5 in. deep, painted and blacked. The quantities vary according to size of boxes and design of castings. To get the full advantage from the larger machine it is essential there should be an electric crane specially for its use.

For large quantities of light castings the Tropenas vessel or electric furnace are to be recommended.

To insure sound steel castings it is essential to have in the first place a good steel, that is, steel containing the correct composition for the work required, and properly "killed," in order to ensure it lying quietly in the mold. It is also essential that the sand be suitable; if being used green, it should have just the correct moisture, and just sufficient bond to work it. Sand, in the first place, should always be dried before milling in order to get the required moisture by adding water, and the necessary binding material. The author prefers to use the natural sands whenever possible. The sands generally used in England for steel castings are Belgian loam, used either by itself or with a small amount of silver sand, cornish loam with silver sand, and Yorkshire sand with silver sand. Of the three mentioned, the author prefers Yorkshire, as it is easy to work, is tough, but not too close, gives a good skin on either dry or green-molded castings, and does not cake in the mill as much as the first two. For cores, the author's practice is to mix eight parts of silica to one of Yorkshire and up to 4 to 1 for molds, varying, of course, according to weight and design.

Running and Feeding.

Where possible the best system is bottom runners, and in one of the thinner sections of the casting. Careful judgment is required for feeding heads to have the required size and in the right place in order to get a

solid casting and avoid wasting steel.

Very soon after casting all runners and feeding heads should be released so as to enable the contraction to take place and avoid having a pull in the casting.

When the pattern is made, it should in the first place be taken into consideration as to whether the casting is to be made green or dry, and the decision generally arrived at is based on how much machining is to be done on the casting, and whether the difference in the two methods of molding is worth the risk of making an unsound casting by making it in green sand. A further consideration depends upon design of the casting. In such cases it is essential to make it green to allow for the contraction strains taking place and preventing the casting pulling into pieces. In some cases the weight and design must be taken into consideration in deciding these points. If there is no danger of the casting pulling with a dry-sand mold owing to design, it is always safer to produce a sound casting from dry-sand work than from green-sand work, owing to the properties of the steel used for casting. Of course, there are many different designs of castings to be contended with, and the greatest trouble given to a steel foundry manager is often caused by the designer not having had any steel foundry practice. To produce good, sound steel castings it should always be the aim to have the thicknesses of the metal as much alike as possible. Wherever thick or bulky pieces of steel are joined together with lighter sections, means have always to be found (if the design cannot be altered) to overcome the difficulties encountered. This can be achieved, either by using chills or causing the thick portion to freeze approximately at the same time as the thinner sections. In some cases, however, a reinforcement is used, but this is not always a wise policy, owing to the possibility of a mishap, after the casting is put to work, disclosing the reinforcement in any fracture. Naturally, the blame would straightaway be put down to this method. This can be further illustrated by a large mill pinion casting of, say, 2 ft. 6 in. tooth face by 3 ft. diameter in the tooth portion, reduced down to, say, 18 in. or so on the neck portion. The best method of producing this class of casting is to have it cored out. At times, however, it is found that engineers object to this method of coring out. They state they must have a solid casting. In order to meet their views, as far as possible (which steel founders, of course, have to do), it is endeavored to produce a solid casting. This, however, is an impossibility without some method of reinforcement, as it is impossible to feed the body portion of the casting of the dimensions mentioned, through the size of the neck and the wobbler. Therefore, the method of reinforcement has to be used. This is accomplished by putting in what is called locally, a "dummy," sufficiently large to prevent the pipe right through the top neck and wobbler, which would take place unless something of this description was carried out.

Again in the case of hydraulic cylinders, in most steel foundries, there does not seem to be any set way in which to cast them. This is done, either mouth downwards or upwards, but in any case there should be taken into consideration the location of the large bulk of the steel and the best means of feeding it. As will be realized, it is necessary to feed all steel castings from the head. In iron foundries, a wrought iron, or mild steel feeding rod is used, and small shanks of metal are poured in time after time until it is set. This method cannot be adopted in a steel foundry, as it would pull out the steel instead of causing it to become more solid as in the case of iron castings.



Fire Hazards in Plants Using Pulverized Coal

The Writer Cites Various Cases Where Fires and Explosions Originated from the Improper Handling of Pulverized Coal—Many Hazards Connected to the Apparatus Used for Pulverizing.

By L. D. TRACY*

Coal Mining Engineer, U. S. Bureau of Mines

SOME one has said that the best way to fight fires is to prevent them, and it is along the line of fire prevention rather than fire fighting that this paper has to deal, for, after all, a fire in a building in which pulverized coal is being used is not fought differently than a fire under similar circumstances, but omitting the coal dust. There are perhaps one or two additional dangers which will be mentioned later.

The hazard in pulverized coal lies in its ability to start trouble so that the principal function of the heads of a fire department in that connection would seem to be to rigidly inspect plants in which this type of fuel is used and to impress upon the owners and operating force the absolute necessity of keeping to the minimum, conditions which would tend to cause and ignite a cloud of coal dust.

It will be noticed that the term "cloud of coal dust" is used. Pulverized coal in bulk is not especially hazardous but as soon as it is raised into a cloud and mixed with air it becomes as dangerous as an unconfined body of gas.

It takes only a small quantity of coal dust per cubic foot of air to cause a very explosive mixture. In tests by the Bureau of Mines a mixture of 0.032 of an ounce of Pittsburgh Coal dust per cubic foot of air has been sufficient to cause an explosion when brought in contact with a flame. Perhaps this can be better understood when it is realized that all that is needed to produce such an explosion is the amount of coal dust that can be held on a silver quarter of a dollar mixed with the air contained in a 12 in. x 12 in. x 12 in. box and this mixture brought in contact with an open light.

As an illustration of what such a combination of dust cloud and open lights may do, the fire in a coal crushing plant connected with one of the steel mills in the Pittsburgh District may be cited. This was a very simple plant used for crushing lump coal for auto-

matic stokers at the boiler plants. The coal was dumped from the railroad cars into a small hopper which fed by gravity into the crusher. From the crusher the coal dropped through a chute to the foot of an elevator by which it was elevated to a small bin, from whence it was delivered to railroad cars on a track depressed some 20 feet below the upper tracks. The elevator was partly closed on three sides, but at the foot it was open on the side toward the depressed track.

As the coal was dry a cloud of dust surrounded the plant during the crushing operation.

Early one morning the chutes became clogged compelling the crusher to shut down. Half an hour later five men went to the foot of the elevator to clean the chute. For lighting the elevator shaft, when such clogging occurs, there are two incandescent lamps, attached to a wooden cross-pipe and connected by a flexible rubber covered wire, to the regular lighting circuit on the platform. These lights were lowered when the men went below the platform, but to provide additional light, one of them carried a lighted torch; a strong wind was blowing which extinguished the torch light.

It was stated that the last man could barely have reached the bottom of the elevator when there was a burst of flame which killed three men, badly burning a fourth who died a few hours later at the hospital and painfully burning a fifth, who recovered. The cause of this accident was supposed to have been the lighting of a match in order to relight the torch and by doing so ignited the dust cloud at the foot of the elevator.

About a year ago the writer was requested by the officials of one of the largest steel companies in Pittsburgh to look over part of the plant handling the coal for their by-product ovens. The buildings were of inflammable construction and covered with fine coal dust and as a result of this inspection the Bureau invited a number of the Foremen of the mill to the Ex-

*Published by permission of Director of U. S. Bureau of Mines.

perimental Mine of the Bureau to witness a demonstration of the inflammability of powdered coal. A large funnel was connected to a compressed air line and a short distance away a piece of burning waste was placed on a small rod driven into the ground. The air was turned on, raising the coal dust into a cloud which was blown across the burning waste.

Another form of coal dust which is exceedingly dangerous and to which perhaps too little attention is paid is the dust coming from small heating furnaces in which pulverized coal is used as fuel. These furnaces are comparatively small and are used principally to heat bars and rods for small forgings, nuts, bolts, etc. They are somewhat like the old style blacksmith forge, having, generally, a hood over the fire to carry away the fumes. The pulverized coal is shot in under pressure and sometimes all of it is not completely burned and goes off into the surrounding atmosphere as floating dust which finally settles all over the platforms around the furnaces, the beams and girders of the buildings and any other place upon which it can lodge.

The writer made an investigation of a plant in which this condition existed and found this kind of dust all over the building. Samples were taken and analyzed. Many of these samples were not much different than a poor grade of pure coal.

Now as to the effects of such dust when looked upon from the viewpoint of a fire hazard. Let us take the case of a fire at the Burden Iron Works, Troy, N. Y. This plant contained about 80 puddling furnaces about one-fourth of which were using powdered coal as fuel. In front of each puddling furnace was a one-ton steel bin which was filled with powdered coal by means of a screw conveyor. From the bottom of the hopper the pulverized fuel dropped into a small screw conveyor by which it was fed into the burner.

The building proper was of ordinary mill construction with heavy wooden trusses. It was stated that these trusses were thickly covered with dust, as the flat surfaces were of comparatively large area.

On the night of the fire the coal dust was leaking in small quantities from one of these bins and falling on the floor. All the doors in the side walls of the building were open and puffs of wind blew little clouds of coal dust in front of the furnace. As the operator was pulling a heat, some of this dust came in contact with the hot slag and was immediately ignited. Instantly there was a flash and the resulting flame reached up into the roof trusses. So quickly did the whole roof become ablaze, that the men had to drop their tools and run for their lives.

A rather peculiar accident happened in one of the Pittsburgh steel mills. At one point in the building was an electric switch so situated that dust could settle between the poles. One Sunday when the mill was shut down, sufficient dust had accumulated to form a short circuit and as a result a whole panel of the switchboard in the power house was burned out.

The incidents which I have mentioned were practically all due to the dusty and unclean condition of the buildings.

There are some hazards however which are more or less connected with the apparatus used in pulverizing the coal and delivering it to the point of consumption. And while it is true that the reduction of the fire and explosion risks rests largely with those operating the plant in question, yet much can be done

through proper inspection by well informed authorities having proper jurisdiction, for instance, such as may come under the regular fire departments, of our cities. And in order to properly understand these hazards and their remedies a working knowledge of the methods and machinery used in pulverized fuel plants is necessary. While it is utterly impossible, in these few minutes, to go into detail, yet perhaps a brief description of some of these methods and machinery may be of some value.

Before coal in a very finely divided state can be used for fuel, it must be crushed, dried, pulverized and then conveyed to the furnace or boiler where it is to be used. Generally speaking there are three distinct classes of pulverized coal equipment in general use and which may be designated as (a) the circulating system, (b) the indirect system and (c) the unit system.

The first two mentioned systems employ practically similar processes, varying perhaps in detail, but differing in the manner in which the pulverized coal is transported to the furnaces.

In the circulating system, after the coal has been pulverized, it is fed in regulated quantities to a fan, by which it is forced in a cloud through pipe lines, ranging from 8 or 10 inches in diameter to 14 to 16 inches. Branch lines leading from the main line to the furnaces carry the coal as may be needed; the surplus coal, which has not been drawn from the main line, returning near the point of beginning where a separator removes the coal dust from the air, and returns it to a storage bin, again to be blown through the line.

In other words it is a continuous circulation of coal dust, and is somewhat analogous to a gas line where the fuel is drawn off as needed. Secondary air lines, independent of the main coal feed line, provide additional air at the burners necessary for proper combustion.

The indirect system transports coal either by compressed air under perhaps fifty or ninety pounds pressure, a screw conveyor, or a combination of air and screw conveyor to bins at the furnaces. From these bins the pulverized coal drops into a small screw conveyor by which it is either fed to an air blast which carries it into the burner, or fed directly to the burner.

The unit system differs from the previously described systems in that the fuel is pulverized at or near the point of use and delivered from the pulverizer in a stream of air directly into the furnace by means of a fan which is a part of the pulverizer.

An important feature of this method of utilizing pulverized coal is contrasted with the circulating and direct systems in the absence of a drier to drive out the moisture.

There are two types of these driers, the direct fired and the indirect fired.

The former type consists practically of a long shell from 3 feet to 5 feet in diameter at one end of which is a furnace and at the other end a stack. The hot gases pass through the center of the shell, coming in contact with the raw coal which is fed into the drier at the stack end.

The indirect fired drier is generally one of two kinds. One kind is the double shell type in which there are two shells, one inside of the other, the raw coal traveling through the inner shell and the hot gases in the opposite direction in the space between the two shells

and then returning through the inner shell to the exhaust stack.

The other kind is an inclined single shell, the higher end of which terminates in a brick housing supporting the exhaust stack, the lower end in a steel hood. The furnace for heating the drier is placed between the stack chamber and the hood. The furnace is provided with a large combustion chamber through which the drier shell passes. The hot gases from the furnace fire circulate around the outside of the drier shell passing through the combustion chamber of the furnace.

In the opinion of the writer the drier is directly and indirectly the cause of a large percentage of the fires and explosions which have occurred in coal pulverizing plants, and on the man running the drier, and by that I do not mean the man in general charge, but the man actually shoveling the coal, is placed a great responsibility, exactly in the same way that the man in charge of a battery of boilers has a heavy responsibility. I sometimes think that the average factory or power plant superintendent little realizes the fact. In the case of the man tending the boiler, if he forgets to keep his water in the boiler at the proper level, something pretty costly is liable to happen. If the man tending the drier furnaces happens to improperly perform his duties and allows it to become overheated, the chances are that there will be work for the fire department in that vicinity.

This is very finely illustrated by an explosion and fire which occurred in a large steel plant in Ohio. From evidence obtained at an investigation it is pretty well established that the man tending the furnace of the drier for some reason built up an abnormally large fire so that the coal in the drier ignited, passed into the pulverizer where it came into contact with the fine coal dust with the result that there was an explosion filling the entire building, killing two men and badly burning two others.

Another case in Ohio of a fire, fortunately not injuring any one nor causing serious damage, was due to a slight amount of coal remaining in a compressed air line. Some repairs were to be made in the line and the pressure was supposedly shut off as the pressure gauge registered zero. When the line was broken, a cloud of coal dust was blown directly toward the open door of the furnace drier by a slight air pressure remaining in the line. Immediately there was a cloud of flame which filled the room.

Another plant which the author of this paper visited after an explosion in which two men were fatally and three men painfully burned, had such a hot fire that sparks were flying out in showers at the point where the shell passed through the combustion chamber.

The above illustrations have been given in order to bring before you actual instances of fires and explosions which have been due either directly or indirectly to driers. It would serve no purpose however, unless some lessons might be drawn therefrom by which you could benefit. One thing every Fire Department Chief can do and that is to insist upon absolute cleanliness in a coal pulverizing plant. Dust accumulations must not be allowed and there is one principle that should be remembered. In cleaning up a plant, coal dust should never be swept up with a broom nor should accumulations be dislodged from window ledges, girders, boiler housings or platforms by blowing with compressed air, unless they have been thoroughly wet down or mixed with incombustible dust

in the proportion of 7 parts of rock or shale dust to one part coal dust. There are some plants which I have seen that are kept almost spotless by a vacuum system. Another safeguard is to see that the drier is isolated from the rest of the pulverizing plant, if not in a separate building then by a blank masonry wall.

A point which will be of interest to you, is that when you see a building the inside of which is covered with coal dust, you can be sure that if it once starts burning, the fire will spread with far greater rapidity than in a similar building which is clean. In fighting a fire of this nature there is one thing to guard against, and that is a sudden explosion or back fire due to pulverized coal, which may be stored in a bin, being suddenly raised into a cloud, either by a sudden air draft, or perhaps by falling material, and becoming ignited. Every district and battalion chief should familiarize himself with the location of all pulverized coal bins in his district the same as he would the location of permanent oil tanks.

All driers should be equipped with recording pyrometers which shall make a continuous record of the temperature at which the drier is operated. Preferably this chart should be placed in the office of some responsible official, and the thermocouples, or that part of the pyrometer affected by the change in temperature, should be installed at the discharge end of the drier.

One of the greatest sources of fire in a drier room comes from the continued passing of hot gases from the drier furnace through the drier shell when the drier is not in operation. That is when the shell is not revolving and there is not a constant stream of coal passing through the drier. In such a case there is very liable to be a certain amount of coal lying in the drier shell which, by the continued contact with the hot combustion gases, will in time become ignited. Then when the drier is again put in operation this hot coal will either be delivered to the pulverizer or to the dried coal storage bin. If it goes to the pulverizer it is liable to ignite and explode the fine dust therein. If to the dried coal storage bin, there is a possibility of it starting a fire by spontaneous combustion. Or by the continued application of heat from the drier furnace, gas may be generated from the coal in the drier, collect in the shell and explode with disastrous results if brought in contact with an open flame.

While this regulation is largely a matter for the operating official, yet an enactment by the proper authorities requiring all driers to be equipped with by-passes in order to prevent the gases of combustion from entering the shell when it is not in operation will be of great value.

Next to the drier one of the most prolific sources of trouble is the large main which circulates the mixture of air and coal dust around the plant, returning the unused coal to the storage bin. The pulverized coal is driven through this line by air currents induced by a fan and having a pressure of about 8 or 9 ounces per square inch. The fires in this line are often of a smouldering nature which heats the pipe red hot. Should you be called to extinguish such a fire, there is not much that can be done save cutting out the hot section. In any event the blowing fan should be stopped. And the most important precaution of all is that the entire line should be inspected to see that it is entirely free from sparks, glowing particles, or smouldering coal before the fan is again started. Otherwise there may be just enough dust lying in the bot-

tom of the pipe line to make an explosive mixture when raised into a cloud by the starting of the fan which will cause trouble if brought into contact with any glowing particles. So, I would again say that after a fire in a coal circulating line, thoroughly inspect the entire line before starting the fan. An illustration of what will happen if this is not done may be of value. At a manufacturing plant which had a large number of small furnaces drawing fuel from this line, the main fan suddenly broke down and stopped running. The sudden cutting off of pressure evidently permitted a back draft and drew hot particles of coal into the pipe line, where they continued to smoulder until several hours later when the fan was again put in operation. The air current thus started stirred up the dust which had settled to the bottom of the pipe when the fan had stopped; at the same time the smouldering coal was fanned into a flame. The result was an explosion which travelled the entire length of the pipe line, ending up by blowing into pieces the cast iron housing of the fan, killing one man and burning two. From the foregoing illustration it is perhaps needless to say that all pipe lines having to do with the transportation of pulverized coal should be of metal.

At this point it might be well to say that all elevator systems and all screw conveyors should be constructed dust tight. This type of apparatus is probably the worst offender in the matter of throwing off fine dust which will remain in suspension for some time and then settle on any flat surface that it finally reaches. It is a very easy matter to allow the joints to become loose and the cover to jar off.

In the case of elevators it is a safe precaution to have them adequately vented to the outside air. However there is one point to be closely watched in all outside vents connected with pulverized coal and that is that the dust is not discharged in the open air in such a manner that it may be drawn in the doors or windows or settle on the roof of another building.

It is in preventing things of this sort that fire departments are able to cooperate by rigid inspection.

Another source of trouble to users of pulverized coal has been due to fires in storage bins. These bins are of two kinds. Those which have a capacity of fifteen tons or so of dried coal and those which range from one ton to 5 tons each and in which the pulverized coal is kept.

There can be but little doubt that spontaneous combustion plays a large part in the origin of these fires.

I regret to say that there is very little reliable data to be had about spontaneous combustion of coal under the conditions found in pulverized coal plants. Data that relate to amount of air required to circulate in the bin, the temperature to be reached before the coal will begin to rapidly heat, etc. We do know, however, a few things about the spontaneous combustion of coal under other conditions and which may possibly be true under the conditions in question. One is that very fine coal presents a greater area to the air than the same bulk in larger sizes, and therefore, will take up oxygen at a more rapid rate, and that burning is no more or less than a rapid absorption of oxygen. That once coal is heated by other agencies to a temperature of 150 deg. or 175 deg. Fahrenheit, from then on the increase of temperature by conserving its own heat is very rapid and not a great deal of time is necessary to elapse before the temperature of rapid combustion is reached.

The following instances are taken from the records of the "Bureau for Safe Transportation of Explosives and other Dangerous Articles," which is affiliated with the American Railway Association.

Smoke was noticed coming from box car loaded with pulverized coal in bulk. The side doors were opened for ventilation. At first actual fire could not be detected, but the entire load was hot and smoke was rising from the surface of the coal.

Three hours later the fire was seen coming to the surface. Efforts were made to transfer it, but the dust and gas ignited where the men were shoveling, so finally the car was brought to a fire plug and a stream of water was used on the dust from time to time. It was finally necessary to wash the entire load out of the car with a stream of water.

Another case was that of a shipment of pulverized coal in bags. When the doors of the car were opened, smoke came out in great volume. Several bags of the pulverized fuel which had ignited spontaneously were unloaded from the car and the fire extinguished.

One of the large steel companies in the Youngstown district, a subsidiary of the United States Steel Corporation, stated that they had experienced more or less trouble with fire in their pulverized coal bins. There was no way as far as I know, in which burning coal could be transported to and delivered into the bins. These bins were, however, lined up in close proximity to the heating furnaces and so absorbed a great deal of radiating heat. On the other hand these bins were not of especially large capacity and probably were supposed to be emptied every 24 hours. In studying the situation as to the cause of these fires the following conclusions seemed to be logical:

It is a well known fact that, for some reason, pulverized coal will stick to the sides of the bins and in time become so caked that it is necessary to jar the bins or use bars to loosen the caked coal. In this case the coal fed to the furnace comes entirely from the center.

It is also a well established fact that pulverized coal, or even slack coal, stored in close proximity to a furnace, steam line or stack for exhaust gases heats up much more quickly than otherwise. As the furnaces in question often caked and were very close to the heating furnaces, it is reasonable to assume that the coal clinging to the side was heated by the heat radiating from the furnaces and in time reached a temperature high enough to cause combustion.

It is well, therefore, to have all storage bins and furnace bins containing pulverized coal as far as consistent with operating requirements from furnaces and away from open lights and flames. Locations of such bins should be such that no radiation from furnaces, boilers, steam pipes, flues or other heating appliances can materially raise the temperature of the contents of the bin. Where practicable bins used in connection with pair and sheet furnaces and annealing furnaces shall be placed outside of the main building. Where this is not practicable they should be separated from the bin by a non-combustible partition.

Where a bin has any large amount of burning coal therein, there is one danger that must be guarded against in efforts to extinguish the fire.

If a stream of water is poured on red hot coal there is a likelihood of carbon monoxide gas being generated, and should the bin be in a confined space there is

great danger of men being overcome, as carbon monoxide is one of the most poisonous gases ordinarily met with, and a fraction of a percent is deadly when breathed. In the case of a bin of pulverized coal, should a stream of water having any force be placed on the pile, there is the possibility of raising a cloud of dust and having it ignite.

Probably the quickest, safest and most economical way is to get all the coal out of the bin as soon as possible, let it lie in a pile outdoors until the fire is entirely out.

Very often fires occur in driers and the right method of extinguishing it is a matter which requires some little judgment. If the fire has not gotten very hot, it may be put out with water. However, if the fire were to burn and the drier shell get red hot it would hardly do to put water in at that time. While I have no personal knowledge I understand that live steam is a very effective and safe way of putting out a fire in a drier.

In all coal pulverizing plants, electricity plays a large part and it may prove of assistance to you, in your fire prevention work, to know some of the hazards for which to look in a plant using pulverized coal.

In the first place all electric wires and cables should, as far as possible, be carried in conduits. At one plant visited by the author of this paper the bin for pulverized coal also acted as a support to wires carrying several hundred volts of electricity.

All switches should, if possible, be placed on the outside of any building in which coal dust is liable to accumulate; if this is not possible, they should be of the oil immersed type. The necessity for this is shown in the incident mentioned in the first part of this paper in which a switch was short circuited by dust and burned out a switchboard panel.

Motors which are liable to spark are a potential source of danger. Perhaps the best illustration of the danger of coal dust is the explosion which occurred at the New Brancepeth Colliery in England. The pulverizer was operated by a 25 hp 500 volt dc motor. The motor was enclosed but not explosion proof and stood on a platform about six feet from the floor. A short circuit of one of the armature coils caused much sparking, thereby igniting the coal dust inside the motor casing, causing an explosion of sufficient force to blow off the sheet iron cover over the commutator end of the motor.

The flame thus produced was sufficient to explode the fine dust held in suspension within the building, the resulting flames extending six feet outside the open door and for a height of 15 feet.

The United States Bureau of Mines and prominent English authorities have made extensive tests in order to determine whether or not a cloud of coal dust can be ignited by an electric arc or spark. For instance with a direct current of 100 volts and 100 amperes in 62 trials ignition was obtained in 20 cases when the arc was formed. With a direct current of 240 volts and 27 amperes in 23 trials ignition was obtained in 19 cases. A motor of five horsepower on a 220 volt circuit ignited a dust cloud once out of every ten trials, while a ten horsepower motor on the same voltage ignited a dust cloud almost every time. Therefore motors of the non-sparking type, preferably squirrel cage motors, are the nearest explosion proof motors now available. All machinery should be thoroughly grounded to prevent sparks due to static electricity.

Whenever inspections are made of fire hazards around any kind of plant where there is a prevalence of dust, whether it be pulverized coal or fine grain dust, aluminum dust, or, in fact any kind of dust, very great attention should be given to the electrical equipment and especially sparking, motors, exposed switches and electric wiring.

When portable electric lamps are used to illuminate any place in which there is liability of a pulverized coal dust cloud forming, the bulb should be protected with a wire guard. There is, however, a danger in using these portable lights around dusty bins because of possible defective connections and short circuits. Ordinary hand flash lights are handier and safer.

In closing, I would impress upon your minds one thing, that a cloud of coal dust and air mixed in the proper portions are as dangerous as a cloud of unconfined mixture of natural gas and air; that a structure covered with coal dust, even though the dust has been partially consumed, will be a hard proposition to fight, once it catches fire, because if this dust once gets in suspension in the vicinity of flames, the probability of an explosion is very great, and an explosion which would have no mercy on any of your men who might be fighting the fire in the vicinity. Every district and battalion chief should acquaint himself with those plants using pulverized coal in his vicinity, and familiarize himself with the plant lay-out and at the same time rigidly inspect it, keeping in mind the old saying "Cleanliness is next to Godliness," and that it is far easier to prevent a fire in a coal pulverizing plant, than it is to put it out, once it is started.

POWER AND MECHANICAL EXPOSITION

Announcement has been made of the National Exposition of Power and Mechanical Engineering to be held at the Grand Central Palace, New York, from December 7 to 13, inclusive (except Sunday intervening) by the managers of the Exposition.

The Exposition was decided upon by a group of engineers and manufacturers who had felt the need for such a means of having men get together, exchange ideas, see the latest development in equipment and lay problems before the manufacturer.

The business opportunity where a manufacturer may meet a large assemblage of power plant and mechanical engineers and capitalists interested in power, is significant to firms keen for such business. A number of progressive manufacturers have already engaged space for their exhibits.

The Exposition will immediately follow the annual meeting of the American Society of Mechanical Engineers and it is expected that the exhibits will supplement the programs and discussions at the professional meetings of the Society. The Professional Divisions of the Society will hold sessions relating to Fuels, Stokers, Steam Power Plants, Railroads, Steam Utilization in the Paper Industry, Textile and Gas Power, and it is expected that the exhibits at the Exposition will throw interesting light on the papers presented at these sessions of the A.S.M.E. meeting.

That the Exposition will be comprehensive may be inferred from the plans which are to include exhibits of every type of machine, apparatus, equipment, instrument device, and the various materials and supplies necessary in the operation of the complete power plant. The Committee decided that its keynote should be "an Exposition of apparatus employed in the generation, distribution and utilization of power."

LETTERS TO THE EDITOR

DOMINION IRON & STEEL COMPANY, LTD.
Head Office and Works, Sydney, Nova Scotia
Canada

OFFICE OF ECONOMY ENGINEER

June 16, 1922.

Editor Blast Furnace and Steel Plant,
Pittsburgh, Pa.

Dear Sir—I have read with much interest the article by Mr. F. G. Cutler on the "Reduction of Fuel Wastes in the Steel Industry," published in your issue of May.

It is a subject that in all industries is deserving of far more study than it has had in the past.

A statement is made, however, which would seem to call for some comment or correction. In referring to by-product gas the writer says, "As gas holders of sufficient capacity to absorb the fluctuations have not been found advisable, it becomes necessary to schedule the use of gas by consuming departments in order partially to equalize the consumption." That is just what has to be done where there is no holder, but if such conditions obtain in any plant where there is a holder it must be that the holder is wrongly placed or far too small. Otherwise, except for great variations, such as a radical change in production schedule at the ovens or the shutting down for a long time of one of the main consuming departments, a remarkably uniform pressure can be held.

Assume a plant producing 12,000,000 cu. ft. of surplus gas per day. A million foot holder would provide for all ordinary disturbances and its cost is almost negligible compared with the economies which can be demonstrated.

While I cannot claim that the mantle of any prophet has fallen on me yet I will venture the assertion that the time is not far distant when gas holders will be used to control the pressure of blast furnace gas, or for combined blast furnace and coke oven gas.

We cannot expect to get continuous high efficiency out of boilers or stoves fired with gas unless the pressure of the gas is reasonably uniform. Nor can high boiler rating be continuously obtained under the same conditions except at the expense of serious heat loss at times of high pressure.

By regulation of the gas pressure and supplying the air by means of a constant speed fan there is no reason why much higher efficiencies cannot be obtained and the necessary expenditure will be small compared with the saving made in the fuel balance for the entire steel plant.

Coke oven gas or tar, or a combination of the two, or a combination of coke oven gas and blast furnace gas, actually show a much lower Btu. consumption in open hearth furnaces than producer gas, because with the latter a very considerable producer loss has to be accounted for, and coke oven gas or tar, or producer gas, with air supply regulated by a fan, shows from 30 to 50 per cent lower Btu. consumption than for the same fuels with natural draft.

Except in rare cases it is hard to justify the use of waste heat boilers—particularly in new installations. The

installation of proper apparatus and situ to better advantage and at a lower cost than to carry it elsewhere with the consequent loss and added installation necessary to recover it in the form of steam.

Yours very truly,

F. E. LUCAS,
Economy Engineer.

MEETING OF ELECTRIC STEEL FOUNDERS' RESEARCH GROUP

Officers and operating officials of each plant holding membership in the Electric Steel Founders' Research Group held one of their regular meetings, for several days, immediately following the convention of the American Foundrymen's Association at Rochester, N. Y. The group meeting was held at East Aurora, N. Y., because of its accessibility to Rochester, where the group members had participated in the foundrymen's annual meeting. C. R. Messenger of Milwaukee, who is very active in this research group and is prominently connected with several foundry concerns including the Sivyver Steel Casting Company, was selected at Rochester as the next president of the American Foundrymen's Association.

Recently in the technical press there appeared an extensive description of the co-operative technical plan followed by this research group, which is made up of representatives of the Electric Steel Company, Chicago; the Fort Pitt Steel Casting Company, McKeesport, Pa.; the Lebanon Steel Foundry, Lebanon, Pa.; the Michigan Steel Casting Company, Detroit, and the Sivyver Steel Casting Company, Milwaukee. At the convention of the American Foundrymen's Association the results of comprehensive investigations in testing molding sand were presented by R. J. Doty of the Sivyver Company, who had been delegated by the group to carry on such a research for its own account. The group made some of its information on the subject available to the industry at large. The result of this, as announced at the foundrymen's convention, has aroused great interest, particularly as it was stated there that certain testing methods developed by the research group have been approved by the sub-committee on tests of the Joint Committee on Molding Sand Research organized by the American Foundrymen's Association and the National Research Council, and participated in officially by the American Society for Testing Materials and numerous technical departments and bureaus of the U. S. Government.

It is stated that at East Aurora further steps for the group molding sand investigation were planned, and interesting reports were presented by the members on annealing, electric furnace practice, the elimination of slag in castings, and other matters that now engage the attention of the group members.

STEEL COMPANIES CONSOLIDATE

Plans will probably be consummated at the meeting, July 7th, of the directors of the Penn Seaboard Steel Corporation, Philadelphia and The Carpenter Steel Company, Reading, Pa., whereby the two companies will consolidate their business.

NEWS OF THE PLANTS

The Donner Steel Company, Inc., Buffalo, N. Y., has disposed of a bond issue of \$5,000,000, a portion of the proceeds to be used for general expansion, additions to working capital, general financing, etc. The company's plant now comprises over 65 acres of land, improved with two blast furnaces, ten open-hearth furnaces, blooming mill, plate mill, billet mill, three merchant mills and other miscellaneous works buildings. Production is devoted to pig iron, blooms, billets, slabs, small shapes, sheared plates, etc. William H. Donner is president.

The Colonial Steel Company, Keystone Building, Pittsburgh, Pa., has plans nearing completion for the construction of a new one-story plant building, on property recently acquired at 2121 St. Clair Avenue, Cleveland, Ohio, to be used as a general heat-treating works. The estimated cost has not been announced.

The Empire Tube & Steel Company, College Point, L. I., will commence the immediate construction of a new plant at Hudson, N. Y., for the manufacture of pipe tubing and kindred steel products. A site has been acquired in the Industrial District. It will be one-story, 100 x 300 feet, and is estimated to cost in excess of \$75,000. The building contract has been let to the L. A. Scott Construction Company, Grand Central Terminal, New York, N. Y. C. J. Thompson, general manager, is in charge.

The Newton Steel Company, Youngstown, Ohio, has arranged for a bond issue of \$750,000, the majority of the proceeds to be used for proposed plant additions for increased capacity. Work will be placed under way at an early date for six new sheet mills, and contract for the structural steel frame for the buildings has been awarded to the McClintic-Marshall Company, Pittsburgh, Pa. It is proposed to inaugurate work at once and have the extension ready for service at the earliest possible date. The present works comprise a total of 10 mills. The company also has plans under way for the construction of a new warehouse.

The Penn Seaboard Steel Corporation, Franklin Bank Building, Philadelphia, Pa., is perfecting plans for the purchase of the plant and business of the Carpenter Steel Company, Reading, Pa., for a consideration said to be about \$8,000,000. The Carpenter works has a present capacity of about 36,000 tons a year, and it is said that the new owner will increase this output in the future.

The Cleveland Structural Steel Company, 6600 Park Avenue, Cleveland, Ohio, has had plans prepared for the construction of a new plant on East Sixty-fifth Street, for a general steel fabricating works. It will be one-story, 60 x 200 feet, and is estimated to cost about \$50,000.

The Gulf States Steel Company, Birmingham, Ala., is planning for extensions and improvements in its plant at Gadsden, Ala., to cost about \$125,000, including machinery and operating equipment. Work will be placed under way at an early date. C. A. Moffett is president.

Following a merger of the Atlas Crucible Steel Company, Dunkirk, N. Y., and the Electric Alloys Steel Company,

Youngstown, Ohio, plans are being arranged for the construction of an addition to the Dunkirk works, to comprise a number of buildings, all to be devoted to alloy steel production. The consolidated company also proposes to build an addition to the present plant of the Electric Alloy division, at Charleroi, Pa., as well as the construction of a new plant at Niles, Ohio. Louis J. Campbell will be chairman of the Board of Directors of the new company, and Arthur H. Hunter, president.

The Sharpsville Furnace Company, Sharpsville, Pa., has perfected plans for extensions and improvements to completely modernize its works. The present blast furnace will be rebuilt and enlarged, providing considerable increase in capacity. A new skip-hoist will be installed; new ore bins constructed, and other work of miscellaneous character carried out. It is said that the expansion program will involve close to \$150,000. The company is operated by the Allen S. Davison Company, Pittsburgh, Pa.

The Steel & Tube Company of America, Chicago, Ill., has disposed of a bond issue of \$6,000,000, the proceeds to be used for extensions in its plant at Indiana Harbor, Ind. The work will include two new mills, bringing the capacity of the plant up to about 100,000 tons per annum. Miscellaneous auxiliary buildings will also be constructed. A. A. Schleisinger has been elected chairman of the Board of Directors.

Gehret Brothers, Bridgeport, Pa., operating a structural steel fabricating plant, have plans in preparation for the construction of a new one-story shop, to be used for general operations. It will be 125 x 140 feet, and is estimated to cost about \$42,000, including equipment. Charles Gehret is head.

The Dominion Alloy Steel Company, recently formed with a capital of \$15,000,000, will break ground at once for its proposed new plant on property in the vicinity of Sarnia, Ont., on the St. Clair river front. The site comprises a total of 1,200 acres of land, including about 370 acres secured a number of months ago by C. Harold Wills, Marysville, Mich., head of the Wills-Sainte Claire Automobile Company, with plans to use the property for a Canadian branch factory. The plant will be devoted to the manufacture of high carbon steel and steel alloys, and is estimated to cost close to \$5,000,000, including machinery. William B. Boyd, Toronto, Ont., is president of the company; George A. Simpson, Hamilton, Ont., is vice president in charge.

The Tichener Iron Works, 7 Frederick Street, Binghamton, N. Y., is considering plans for the construction of an addition to its plant for increased capacity. It is estimated to cost about \$50,000, including equipment. Work will be inaugurated at an early date. L. E. Barnes is secretary.

The Cranberry Furnace Company, Cranberry, N. C., with branch plant at Johnson City, Tenn., has preliminary plans under way for improvements in its blast furnace, to include relining and other work. Hammond Prosser is secretary.

The plant and property of the Connecticut Electric Steel Company, Hartford, Conn., have been acquired by M. W. Taggart & Company, New York.

WITH THE EQUIPMENT MANUFACTURERS

A DIRECT READING RESISTANCE THERMOMETER

Resistance thermometers have certain notable advantages as compared with other temperature measuring devices which make them particularly valuable for many industrial processes. One particular advantage is in the ability to produce a high temperature instrument in which the whole temperature scale may cover a range of 25 deg. F. only. This is very difficult to obtain with a direct reading instrument operating on any other principle.

There are many applications where throughout a process the temperature must be known with extreme accuracy and where the temperature is maintained constantly within close limits. For example, it may be desirable to maintain a temperature of 820 deg. F. and the temperature will never drop

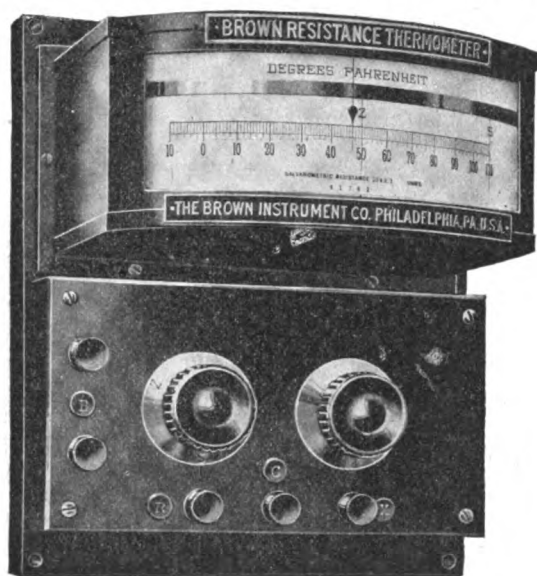


Fig. 1—Brown Direct Reading Resistance Thermometer.

below 750 deg. F. or rise above 900 deg. F. A thermo-electric pyrometer would usually be supplied to meet such a requirement with a total range of 0 to 1,000 deg. F. If the scale can have a maximum of 100 or 150 divisions, each graduation on the scale would be equivalent to 10 deg. F.

If, however, a direct reading resistance thermometer is used, the scale can be graduated from 750 deg. to 900 deg. F., and each division is then equivalent to 1 deg., affording much greater accuracy in the readings.

The fundamental principle of the resistance thermometer is the well-known physical property of metals, except special resistance alloys, of change in resistance with change in temperature. This change in resistance can be accurately measured and a scale calibrated in temperature degrees.

The bulb or coil of wire which changes in resistance is usually of nickel for temperatures to 300 deg. F. (150 deg. C.) and of platinum for higher temperatures to 1800 deg. F. (1000 deg. C.). The dimensions of the bulb can be very small to secure sensitivity. A nickel wire bulb can be supplied with active part 1 in. long and 3/16 in. diameter. This can be supplied in a protecting tube for moderate temperatures with an outside diameter of only 1/4 in.

Three wires lead from the bulb to the instrument. This three wire system eliminates any effect on the indications

of the instrument due to changes in temperature along the wiring connecting the bulb to the instrument. The length of wiring is immaterial in the Brown three wire system and bulbs can be placed up to 1000 ft. distant from the instrument using No. 14 gauge copper wire or up to 2500 ft. distant (half a mile) with No. 10 gauge copper wire.

A recent development has been the perfection of a direct reading resistance thermometer. For years resistance thermometers have been built on what is known as the zero or null basis. In this type of instrument a galvanometer pointer must be brought to zero and a reading is then taken on a scale mounted in front of a rheostat. While quite accurate this method has the disadvantage of not being direct reading and the operator must obtain a balance by adjusting the slide arm of the rheostat so that the galvanometer indicates zero before the temperature reading is secured.

The Brown direct reading resistance thermometer has a scale graduated directly in temperature degrees as illustrated. To check the instrument for zero reading, the left hand knob is turned to Z, and then to S to check the instrument with a standard resistance at the top graduation on the scale, and in the third position the instrument is operated directly off the temperature bulb. The rheostat is the right hand knob on the instrument for adjusting the voltage. This check of the instrument while recommended daily, need only be made every few days even where dry cells are used to operate the instrument, since the current required is infinitesimal, and dry cells last four months without replacement. Where storage batteries are used, a less frequent check is satisfactory.

Through means of a switch, the instrument can be connected to any number of resistance thermometer bulbs installed in different locations. Where used in dry kilns the instrument can be used to measure both temperature and humidity, one bulb being subject only to the air temperature, the second bulb being covered by a wick leading into a tank of water. This type of bulb, for measuring humidity, affords a means of instantly reading the difference in temperature of both the wet and dry bulbs and from suitable tables the per cent of humidity is available. This construction enables the measurement of both temperature and humidity at great distances.

Applications where the Brown direct reading resistance thermometer can be used to advantage are in power plants for many temperature measurements, for the temperature of coal piles to prevent spontaneous combustion, oil cracking stills where extremely accurate measurements of temperature are required, chemical processes, refrigerating rooms, public buildings and schools, for the approach of frazile or anchor ice temperatures in hydro-electric power plants and numerous other applications.

This new direct reading resistance thermometer is the product of the Brown Instrument Company, Philadelphia, Pa.

The Allegheny Steel Company, Brackenridge, Pa., has perfected plans for immediate work on a number of improvements and extensions in its local plant. The present plate mill will be converted into a jobbing mill, and the blooming mill will also be subjected to a number of changes, to provide for the handling of larger ingots and the production of sheet bars, slabs and billets of varying sizes. The remodeled plate mill will be used for the rolling of annealed sheets of widths up to 72-inch.



E. J. Lowry, recently became identified with Hickman, Williams & Co., pig iron brokers, as a service engineer. Mr. Lowry was formerly connected with the Oliver Chilled Plow Works, South Bend, Ind., in the capacity of metallurgist.

✓ ✓

James Walsh, superintendent rolling mills, Illinois Steel Company, South Chicago, Illinois, has resigned to become assistant general superintendent Inland Steel Company, at Indiana Harbor, Indiana.

✓ ✓

E. G. MacKay has retired as superintendent of the steel plant of the Nova Scotia Steel & Coal Company, Sydney Mines, N. S., and will leave shortly for Pittsburgh where he is expected to take an important position.

✓ ✓

William B. Gillies was recently appointed general superintendent of the Mark plant, the Steel & Tube Company of America, at Indiana Harbor, Ind., to succeed A. H. Beale, recently elected vice president in charge of operations.

✓ ✓

John Sincock, general superintendent of W. J. Rainey, Inc., retains his own title and assumes the additional duties at Connellsville, Pa., of L. L. Willard, vice president, who resigned on account of ill health.

✓ ✓

W. B. Pierce, who for 12 years was superintendent of the Buffalo Bolt Company, North Tonawanda, N. Y., and for the past two years connected with the Pierce-Brown Company, that city, has been made works manager of the Graham Bolt & Nut Company, Pittsburgh. Mr. Pierce took up his new duties June 1st.

✓ ✓

T. H. Edwards recently resigned his position as superintendent of steel works department, which position he has held for many years, Benwood, W. Va., Plant of the Wheeling Steel Corporation, and has retired from active connection with the industry. He has been in the steel business for fifty years. Mr. Edwards will join his family now in Denver, Colorado. His successor has not as yet been named.

✓ ✓

Morman R. Seidle recently resigned as assistant general manager of the James G. Heggie Company, Joilet, Illinois, to become works manager of the General Boilers Company, Waukegan, Illinois. The General Boilers Company manu-

factures steel-welded boilers (Pacific type) for all general heating purposes.

✓ ✓

John Dunlop for many years assistant manager of the Wellsville, Ohio, Plant of the American Sheet & Tin Plate Company, has resigned because of ill health. William W. Knox will be his successor. Mr. Dunlop was in the employ of the mill for more than 26 years.

✓ ✓

H. V. Smallwood, purchasing agent at the Portsmouth, Ohio, works of the Wheeling Steel Corporation since 1918, has been transferred to Wheeling and promoted to the position of general purchasing agent, having charge of purchases of raw materials for the entire company. Mr. Smallwood, before going to the Portsmouth, Ohio, works was with the Youngstown Sheet & Tube Company, Youngstown, Ohio, and prior to that with the La Belle Iron Works, Steubenville, Ohio.

✓ ✓

B. L. Morgan was recently appointed superintendent of the Erie Specialty Company, Erie, Pa.

✓ ✓

Fred B. Quigley has been appointed superintendent of open hearth furnaces and the Bessemer department of the Carnegie Steel Company, Youngstown, Ohio, succeeding William C. Bulmer, resigned. On June 1st Mr. Bulmer assumed charge of the sales and installation of water-cooling appliances for openhearth furnaces of the Blaw-Knox Company, Pittsburgh. Mr. Quigley was assistant superintendent of blast furnaces since 1912 and has been connected with the Youngstown district for 14 years, following his graduation from Case School of Applied Science. From 1912 until two years ago he was assistant blast furnace superintendent at the Ohio works, in immediate charge of the company's furnace at Niles, Ohio. Upon banking of the Niles furnace, Mr. Quigley was transferred to the Ohio works.

✓ ✓

Thomas E. Raymond, for three years superintendent of the Clinton, Mass., works of the Wickwire Spencer Steel Corp., Worcester, Mass. and Buffalo, has resigned because of ill health. He is succeeded by George M. Johnston, who has been connected with the same works for 13 years, starting as an office boy at 14.



Albert Maheu, Worcester, Mass., until recently superintendent of the General Spring & Wire Company, Detroit, has taken a position with the Wetherell Bros. Co., Boston, Mass., steel merchants, which company he will represent in New England territory.

V V

Andrew Glass has resigned as vice president in charge of operations, Wheeling Steel Corporation, effective July 1st and will be succeeded by William J. Stoop, who has been assistant to Mr. Glass. The latter, who is a nephew of Alex Glass, chairman Wheeling Steel Corporation, has been identified with the companies now comprising the Wheeling Steel Corporation since early manhood. He was general manager of the Portsmouth Ohio, works, Whitaker-Glessner Company, when the Wheeling Steel Corporation was formed in 1920 and was made president of the Whitaker-Glessner Co. and vice president of the Wheeling Steel Corporation. Mr. Glass will be associated with W. M. MacCleary in a brokerage business in iron, steel and allied products.

V V

W. Woodward Williams has been appointed vice president of Titan Iron and Steel Company, mechanically puddled wrought iron, Newark, N. J. Mr. Williams graduated from Harvard in 1905. After six years in the mills of the Carnegie Steel Company at Pittsburgh, Duquesne and Youngstown, he entered the sales department of the Bowne-Fuller Company, Cleveland, and was later appointed manager of its Pittsburgh office. In January, 1914, he became general manager of sales of the A. M. Byers Company, Pittsburgh, and subsequently was made its general manager. In August, 1919, he became general manager of the Reading Iron Company, and afterward was elected vice president, in charge of sales and operations. In September, 1920, he became associated with the Pittsburgh Gage & Supply Company, the largest jobber of wrought iron pipe in the United States, resigning the vice presidency on May 31, 1922, and entering immediately upon his present office of vice president of the Titan Iron & Steel Co., Inc.

V V

James J. Zimmerman, until recently assistant superintendent of the Mechanical Department of the Reading Iron Company in Reading, Pa., has joined the engineering force

of the Elliott Co. of Pittsburgh and Jeannette, Pa., manufacturers of pumps, condensers and steam equipment.

V V

A. J. Maskrey, general superintendent of the Carnahan Sheet & Tin Plate Co., Canton, Ohio, for 11 years, has been made general manager of the Falcon Tin Plate Company, which recently took over the Carnahan company. Charles A. Streb, paymaster and secretary of the Carnahan company, has been appointed general superintendent of the Falcon company.

V V

M. W. Froney, assistant chief engineer on the Gogebic range for Pickands, Mather & Company, Cleveland, has been made superintendent of the Carey mine.

V V

Albert L. Andrews, one of the founders of the Andrews Steel Company, and the Newport Rolling Mill Company, Newport, Ky., died suddenly at his home in that city, June 19th. Mr. Andrews was born in Cincinnati in 1842 and retired from active business life four years ago at the age of 76. He is survived by three sons, Albert K., Joseph Gaff and Frank N., all actively associated with the management of the Newport Company.

V V

A. B. Neumann, who as chief engineer for the United States Steel Corporation designed and built the Gary plant, and who for the past three years has been chief consulting engineer for the Steel and Tube Company of America, has opened offices as consulting engineer in the Peoples Gas building, 122 S. Michigan avenue, Chicago.

Later he designed and built the East Works of the American Rolling Mills Company. In 1916 he made the layout for the original plant of the Mark Manufacturing Company at Indiana Harbor, Ind., which was constructed in 1917 and 1918.

During the greater part of 1917 and 1918, Mr. Neumann designed and constructed the Pittsburgh Steel Products Company's plant at Allenport, Pa. While he was chief consulting engineer for the Steel and Tube Company of America he laid out and built this concern's two vessel Bessemer plant at Indiana Harbor. Recently he has been engaged in making appraisals of steel, power and manufacturing plants.

Some Pointers on By-Product Coke Oven Operations

AMERICAN COKE OVEN PRACTICE

Dr. G. Lishman and Mr. A. H. Middleton have given their impressions of American coke oven practice, before the Northern Section of the Coke Oven Managers' Association. Mr. Middleton, in the course of his remarks, pointed out that in America, nearly all ovens were made with silica bricks, and that the ovens, in general, were much larger than the British type, being from 10 to 12 ft. high, the coking chambers being about 38 ft., but that the width was only from 15 to 18½ in.

Carbonizing temperatures ranged from 1,250 deg. to 1,350 deg. C. So-called "black ends" were no objection, as blast-furnace men liked to see a little flame when pushing an oven, as they declared it showed hydrocarbons to be present.

American coke, from wall to cleavage point, was more like the medium zone in British coke. One concern in the U.S., over a month's working, used only 15 cwt. of coke per ton of pig iron.

Dr. Lishman said that American coke was very small, that for blast furnaces, resembling good breeze. Wet coal could not be employed, as the silica brick would crumble or fall to pieces after about two years. The present cost of American plant was about \$50,000 per oven, but they were elaborately fitted with all sorts of recorders and meters.

Labor control might be called a more or less benevolent despotism, and there was no cokemen's Union. A ram man, in America, would push and level 80 to 100 ovens per shift, as against the fixed shift of 13 ovens in Durham.

An interesting discussion followed, touching mainly upon by-product yields, which were declared to be quite as high as our own, in spite of the high temperature used, and which might be expected to break them up. Questions were asked and answered, relative to central quenching, the appearance of coke, the use of dry coal, and silica linings.

THE MANUFACTURE OF COKE

In a paper upon the manufacture of coke for industrial purposes, read by Mr. A. D. Young, before the Lancashire branch of the Institution of British Foundrymen, the necessity was pointed out for a hard, non-friable coke, with a well-developed cell structure. It should have a large carbon content, with low proportions of ash, sulphur, phosphorus and water.

Reference is made to the poor quality slacks, from which practically the whole of the coke now produced, is derived, and the process of washing is described. Details are given of the two processes followed in the production of coke for fuel purposes, either by carbonization in bulk in ovens, or by carbonization at gasworks in horizontal retorts.

The early types of coke ovens are expounded upon, of which the beehive oven, which answers so well for certain types of coal, retains its place even down to the present moment.

IGNITION TEMPERATURE OF COAL

In an interesting paper, Ray W. Arms, in the Illinois University Bulletin summarizes his conclusions in the following words:

(a) The "Ignition Temperature" of coal means nothing unless it is applied to some definite point in the process of heating the coal, which can easily be determined and duplicated.

(b) The temperature at which the coal glows seems to be the most logical point to choose as the ignition temperature. It is easily observed, can be duplicated with a fair degree of accuracy, and marks the beginning of visible combustion.

(c) The glow point is probably affected by the oxygen contents of the coal, and perhaps by other agencies made active by weathering.

(d) The glow point is not affected by ash, moisture, size of particles, slight variation from the normal air supply, nor by the rate of heating.

(e) There is at present no indication that the glow point bears any direct relation to the liability to fire whilst in storage. Perhaps if a series of tests were made on the glow points of freshly mined coal, new information would be brought to light, which would lead to the discovery of some more definite relation between the glow point and the firing qualities of the coal.

TEST PROPOSALS FOR COKE FOR BLAST FURNACE AND FOUNDRY PURPOSES

Dr. Koppers in the April 13, 1922 issue of *Stahl und Eisen* has the following to say regarding test proposals.

With proper coke as shown by American blast furnace practice, one ton of pig can be produced with 527 kilos of carbon, gasified by air in front of the tuyeres, and with less highly heated blast than is used in Europe. With our usual higher carbon consumption, the blast-furnace generally suffers from too high a temperature in the shaft.

The writer condemns a number of the usual methods of dealing with this evil, and recommends his own practice, viz., drawing off some of the gases between the bosh and the shaft. He contends that coke, exceeding a temperature varying between 600 deg. and 800 deg., according to the variety of coal, becomes more difficult to burn. Using such coke, therefore, as the shaft temperature reads, the former becomes more and more overheated, and hard to burn.

Analysis shows that the carbon in coke is compounded with certain quantities of oxygen and hydrogen. Tests showed that the specific gravity of a certain coke, upon heating from 700 deg. to 950 deg., actually rose by almost 20 per cent. For blast furnace purposes, coal should be so treated that the specific temperature of the coke does not exceed 650 deg. to 800 deg., according to the quality of coal. The coke should not contain more than 8 to 10 per cent ash, and less than 1 per cent sulphur and 3 per cent water. It should not break into small pieces, and at 700 deg. to 750 deg., a lively evolution of gas should take place.

Foundry coke, on the contrary, should be hard to burn, and made from coal, with the lowest possible amount of volatile matter.

The author favors the inclined hoist above all other means of charging the blast-furnace, and remarks that the latest types of furnace are absolutely dwarfed by huge, subsidiary, but costly iron erections. Skip loaders were tried, he says, in several American works, but abandoned in favor of the inclined lift, which gives more equable charging. He cites the Illinois Steel Co., where one man per shift looks after the charging of a blast furnace, producing 700 tons per 24 hours.

TRADE NOTES

Orton & Steinbrenner Company—manufacturers of locomotive cranes, grab buckets and coal crushers, have moved their offices from the 11th to the 19th floor of the Transportation bldg., 608 So. Dearborn st.

Iron Products Corporation, New York and its subsidiaries The Central Foundry Company, Central Iron and Coal Company, Central Radiator Company, Molby Boiler Company, announce the opening of a district sales office in the Jefferson County Bank building at Birmingham, Alabama.

Combustion Engineering Corporation announce that Mr. A. D. Halporn, who has been associated with their Philadelphia Sales Staff for some time, has now become a member of their New York Sales Force.

J. G. Barry, sales manager of the General Electric Company since 1917 and manager of its railway department for many years and A. H. Jackson of the Law Department, were recently elected vice presidents of the company at a meeting of the board of directors.

Witherbee, Sherman & Company have appointed Freyn, Brassert & Company consulting engineers for the construction of a new blast furnace at Port Henry, New York.

Mr. John F. Schurch has been elected a vice president of Manning, Maxwell & Moore, Inc., and on June 1st will take charge of their western sales, with headquarters at the Company's Chicago Office, 27-29 North Jefferson st., Chicago.

Announcement is made of the incorporation of the Raymond Brothers Engineering Company, Chicago, for the manufacture of equipment for "Rayco" Pulverized Coal Systems for the utilization of pulverized coal as fuel in metallurgical operations, cement plants, and under boilers in power plants, and for the designing and installation of such systems. The new company takes over the business of the American Industrial Engineering Company of Chicago, which has made a number of such installations, and Mr. L. H. Bergman, who has been Secretary and Chief Engineer of the American Industrial Engineering Company, will remain as General Manager of the new company.

The Sanford Riley Stoker Co. has merged its interests with the Underfeed Stoker Company of America and its affiliated companies, the A. W. Cash Co., valve manufacturers, Decatur, Ill., the Craig Damper Regulator Co., Detroit, Mich., and the Underfeed Stoker Co. Ltd.

of Canada. The products of the combined companies, which include the Jones, Riley and Murphy stokers, makes one of the most complete lines of mechanical stokers ever brought together. Manufacturing will be concentrated at Detroit, Michigan and Worcester, Mass.

The Pennsylvania Pump and Compressor Company of Easton, Pa., has recently opened a district office at 105 West Monroe street, Chicago, Ill., with H. M. Montgomery in charge.

Tate-Jones & Company, Inc., Furnace Engineers, Pittsburgh, Penna., report the following contracts closed by them within the last two weeks.

Six (6) furnaces for the Wheeling Steel Corp.

Six (6) furnaces for the Newton Steel Company, Newton Falls, O.

One (1) furnace for Superior Sheet Steel Company, Canton, O.

Equipment for a new power station in the City of Maracay, Venezuela, South America, has been ordered from the Westinghouse Electric & Manufacturing Company by General Juan Vicente Gomez, President of the Venezuelan Republic. The equipment ordered by the Venezuelan President consists of one 500 kv-a water wheel generator; step-up transformers of sufficient size to accommodate two generators; 24 kilometers of transmission line with steel poles and step-down transformers for a sub-station.

The Ever-Tyte Piston Ring Division of the Walter A. Zelnicker Supply Co., St. Louis, Mo., has appointed J. H. Perkoski as their Pittsburgh district representative. Mr. Perkoski has been associated with the Sturtevant Mill Co. for many years as Western Sales Manager and special representative. Mr. Perkoski has appointed Mr. Fred C. Laughran, formerly connected with the Jones and Laughlin Steel Company and Mr. Bernard Perkoski as his representatives to introduce The Ever-Tyte Piston Ring in the steel plants of this district. Several installations in the National Tube Co. and the Jones and Laughlin Steel Co. mills have proven the merit of Ever-Tyte Rings.

TRADE PUBLICATIONS

A line of velocity stage turbines especially designed for high pressure and high temperature steam is described in a 28-page catalogue issued by the De Laval Steam Turbine Co., of Trenton, N. J. The cast steel steam chest is located in the casing cover in order to avoid the conduction of heat to the bearings. In addition to the speed governor and governor valve, there is an inde-

pendent valve controlled by an automatic overspeed trip. The turbines are built in sizes up to 1,200 hp, and are designed to be directly coupled to high speed centrifugal pumps and blowers, small ac and dc generators, and by means of double helical speed reducing gears, to large pumps and blowers, medium size generators, belt pulleys, rope sheaves and slow and moderate speed machinery.

"Regulating Boiler Feed Water" is the title of a booklet which has just been published by the Northern Equipment Company, Erie, Pa. The subject has been treated in an entirely new way, the object being to cover the subject of boiler feed water regulation completely and yet very briefly. To accomplish this purpose, free use has been made of a graphical method of presentation: charts showing the effect of feed water regulation on water input, steam output, feed water temperature, etc., also other charts, photographs, etc. There are only twenty pages and the booklet can be read in less than fifteen minutes.

The Conveyors Corporation of America, 326 W. Madison street, Chicago, have issued an illustrated booklet entitled "Cut Ash Handling Costs" which should prove to be of value to the power plant executive interested in reducing the boiler room overhead.

The Electric Furnace Construction Company of Philadelphia have recently published two interesting catalogues, one on Electric Furnaces for Melting, Refining and Superheating of Iron and Steel, the other describes the "Electro" Steam Boiler developed by F. T. Kaelin, Chief Engineer of the Shawinigan Water and Power Company.

Whiting Corporation have just issued a new railway equipment catalogue No. 160, which supersedes No. 145. This catalogue contains a description of the company's locomotive hoists, coach hoists, cranes, turntable tractors and miscellaneous other equipment.

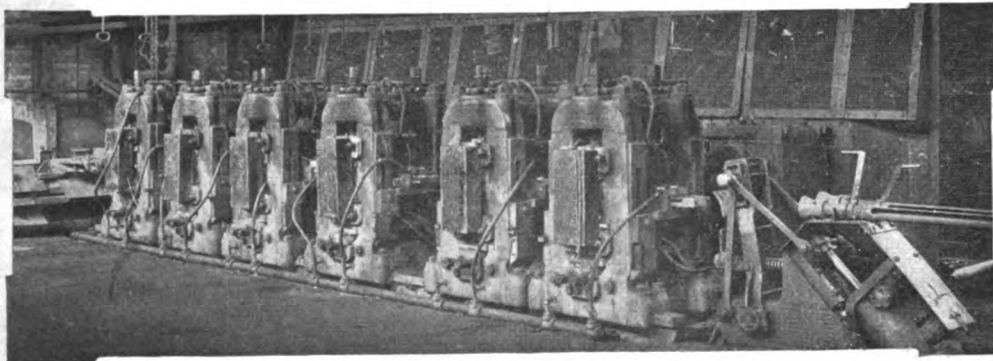
The Conveyors Corporation of America, 326 West Madison street, Chicago, Ill., have just issued a new booklet describing their American Cast Iron Storage Tank, which is designed for holding loose, bulky, dry materials for storage or transfer. The tank is sectional and may be secured in a number of sizes. Copies of the booklet may be secured by addressing the Conveyors Corporation at 326 W. Madison street, Chicago, or on application to their district representatives.

"The Surface Combustion Co., Industrial Furnace Engineers and Manufacturers, of 366 Gerard ave., Bronx, New York City, are issuing a series of bulletins pertaining to industrial furnaces.

The Blast Furnace *and* Steel Plant

Pittsburgh, July, 1922.

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